

Further Malayan Freshwater Flagellata

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MALAYA HAS numerous rivers, swamps, paddy fields and ponds of various kinds, and one would naturally expect to find an abundance of Flagellata in these waters. Despite this, very little is known of the forms which occur in this area, largely because it has been only in recent years that attention has been turned to the freshwater microflora of Malaya. In addition, for accurate determination the Flagellata must be studied in the living state, or at least freshly killed with osmic acid vapour. Most fixatives, like Formalin or alcohol, cause such distortion of the organism that it is recognisable only with great difficulty. Thus, what knowledge we have of the Flagellata is confined to those forms collected from easily accessible places, and as more extensive areas are covered we may expect the number of described species to increase considerably. References to the Malayan freshwater flagellates are few and scanty in content, and with the exception of my own longer paper on the Euglenineae (Prowse 1958), have all been based on preserved specimens examined far from the native habitat. The present paper cannot be regarded as in any way complete, even in those groups discussed in it; the Volvocales, Xanthophyceae and the Dinophyceae are omitted and will be described in later papers.

Most of the material on which this paper is based has been examined immediately after collection, both living, and freshly killed with osmic acid vapour. In some cases, especially with those organisms inhabiting polluted waters, the material has been examined again after keeping it in the laboratory for several days. In a few cases the organisms have been studied in culture, although in no cases were the cultures absolutely free from other organisms. Drawings were all carried out with the aid of a camera lucida, using an Ortholux microscope; any inaccuracies are therefore my own.

Since this paper is not intended to be in any way complete, I have refrained from constructing keys beyond the level of genera. Species are listed alphabetically under the genus. The Euglenineae described here is additional to those mentioned in an earlier paper (Prowse 1958), and as only one genus, *Rhizaspis*, has been added to the earlier list, it has been felt not necessary to construct a new key.

The Flagellata are so called because of the presence of one or more protoplasmic threads, the flagella, by means of which the organism is propelled in the water. Originally the term was used to distinguish naked flagellate forms from those forms such as the Volvocales which possess a cell wall. This distinction is no longer valid, since in the Chlorophyceae there are a few naked flagellate members, particularly in the Polyblepharidaceae, whilst thalloid and filamentous development has also been found in other groups such as the Xanthophyceae, Chrysophyceae and even the Dinophyceae. As now used, the term Flagellata embraces a diverse assemblage of forms belonging to well-defined and differing classes, and includes as well a somewhat heterogeneous collection of colourless forms whose affinities are uncertain. Apart from this latter, which cannot be constituted a true class, each group includes holophytic pigmented forms, and also colourless forms amongst which the mode of nutrition may range from saprophytic to completely holozoic. There are even species containing chromatophores which can display holozoic nutrition (e.g. *Chrysamoeba*) and these often show amoeboid characters, as do several of the colourless forms. The distinguishing features of each group will be dealt with under the class headings, although the key will also include brief reference to them.

KEY TO THE FLAGELLATA

- A. Cells with chromatophores B.
- A. Cells colourless, without chromatophores G.
- B. Chromatophores grass green C.
- B. Chromatophores yellowish green to bright green, not grass green D.
- B. Chromatophores yellowish to brownish E.
- B. Chromatophores variable in colour F.
- C. Cells usually with one chloroplast, rarely more; elaborate vacuolar apparatus "gullet", absent; flagella usually two or four equal in length; storage material starch; complex colonial forms occur . . . VOLVOCALES (Chlorophyceae).
- C. Cells usually with several chloroplasts; vacuolar system elaborate, forming a "gullet"; storage material paramylum EUGLENINEAE (I).
- D. Cells bright green; chloroplasts numerous; elaborate vacuolar system or "gullet" present; trichocysts present in the cell; storage material fat . . . CHLOROMONADINEAE (II).

D. Cells more yellowish green; elaborate vacuolar system or "gullet" absent; chloroplasts usually few; flagella usually two, unequal in length; storage material oil, never starch
XANTHOPHYCEAE.

E. Chromatophores usually brownish in colour (but see F). usually two in a number; cells markedly dorsiventral with a groove or canal where the flagella are inserted; flagella usually two, unequal; storage products solid carbohydrates-starch and allied substances .. CRYPTOPHYCEAE (III).

E. Chromatophores brownish, usually numerous; membrane usually consisting of sculptured plates; flagella two, one transverse and undulatory, often in a groove, the other projecting vertically and free; storage products starch and oil DINOPHYCEAE.

E. Chromatophores golden yellow, usually 1-2 in number; flagella 1-3; cells often with an elaborate envelope; storage products leucosin; colonial forms frequent
CHRYSOPHYCEAE (II).

F. Chromatophores blue, blue-green or red, usually two in number; cells markedly dorsiventral with a groove or canal where the flagella are inserted, flagella usually two, unequal; storage products solid carbohydrates-starch and allied substances CRYPTOPHYCEAE in part (III).

G. Cells colourless, with an elaborate vacuolar apparatus or "gullet"; storage product paramylum
EUGLENINEAE (in part) (I).

G. Cells colourless, distinctly dorsiventral with a groove or canal where the flagella are attached, flagella usually two, unequal; storage product starch or allied carbohydrate
CRYPTOPHYCEAE (in part) (III).

G. None of the above characters
RESIDUAL COLOURLESS FLAGELLATA (IV).

EUGLENINEAE

One hundred and twenty-five species of Euglenineae from Malayan freshwaters have been described in an earlier paper (Prowse 1958), and the following are species or forms additional to that list. No key is provided here, but the genera are listed in the same order as in the previous paper.

The most characteristic features distinguishing the Euglenineae from the other classes, are the presence of a narrow canal or cytostome leading back into an enlarged vacuolar swelling or reservoir, and the fact that the storage product is paramylum, a polysaccharide allied to starch, but not staining with iodine or chlorzinc-iodide.

Euglenaceae

Possessing green chloroplasts, ranging from discoid to band-shaped with or without pyrenoids. The green colour may in some cases be obscured by the production of haematochrome. Colourless forms have appeared which are so obviously related to pigmented forms that there is no difficulty in identification.

EUGLENA Ehrenberg 1838

1. **Euglena agilis** Carter [syn. *Euglena pisciformis* Klebs]. CELLS elongate-ovoid, $18-20\mu$ long \times $9-11\mu$ wide, bluntly rounded at the anterior end and tapered to a blunt point at the posterior end; PERIPLAST very faintly striated, the striae not easily visible. CHROMATOPHORES two parietal plates nearly filling the lining of the periplast, but with the division between them always visible; from the side they appear as elongated bands, but in freshly killed specimens lightly stained with Gentian violet the edges are seen to be lobed. PYRENOIDS one in each chromatophore, usually centrally placed and with a paramylum cup on each side; additional paramylum in the form of a few very short rods. EYESPOT faint, orange in colour. FLAGELLUM a little over body length. The organism swims rapidly, with a characteristic sideways flick of the tail end. (Pl. I figs. h, i).

MALAYA: Malacea—fish-ponds.

Worldwide in distribution.

2. **Euglena exilis** Gojdics. CELLS broadly fusiform $70-85\mu$ long \times $18-22\mu$ wide, rounded at the anterior end, tapering gently to a point at the posterior end. PERIPLAST very prominently striated, the striae seen clearly to consist of rows of dots. The CYTOPLASM contains scattered spherical granules which stain with neutral red, but are otherwise not easily visible. CHROMATOPHORES usually four elongated parietal plates, lobed at the edges, the lobes best seen when the cell has swollen out and is lightly stained with gentian violet. PYRENOIDS one in the centre of each chromatophore, with a cup of paramylum on each side; additional paramylum in the form of small rectangular rods $2-3\mu$ long. FLAGELLUM $\frac{1}{2}-1$ times body length. EYESPOT large, orange red. Cell distinctly metabolic, bulging in the middle and then narrowing down again. (Pl. I fig. k).

MALAYA: Malacea—fish-ponds.

Originally described from U.S.A.

Despite the larger size and fatter shape of the Malayan forms, I have felt it better to place them under Gojdics species (Gojdics measurements are $37-53\mu \times 8-10\mu$). They clearly agree in the striated pellicle, shape and number of the chromatophores, and in

the granules which stain neutral red. The flagellum in the Malayan form is admittedly longer than in the original species from U.S.A. There are distinct affinities with *Euglena polymorpha* Dangeard, which is of a similar size and shape, but that species has 12–20 smaller chromatophores.

3. ***Euglena flava* Dangeard.** CELLS broadly fusiform, $55-70\mu$ long $\times 20-25\mu$ wide, rounded at the anterior end and tapering to a blunt tail at the posterior end. PERIPLAST faintly striated, the striations difficult to see. CHROMATOPHORES 10–15 elongated discs with smooth edges, parietally placed parallel to the long axis and appearing as elongated bands in side view. PYRENOIDS one in each chromatophore with a cup of paramylum on each side, additional paramylum not seen. The cells are coloured red by numerous granules of haematochrome which are either clumped in the middle, or dispersed throughout the cell. FLAGELLUM about body length. EYESPOT a quite large, orange-red concave disc. The cell is distinctly metabolic stretching out and contracting to a round ball. (Pl. I fig. g).

MALAYA: Malacca—small experimental ponds at Batu Berendam.

This species formed orange-red scums in small ponds manured with buffalo manure. Why it should have occurred rather than *Euglena sanguinea* Ehrenberg, to be found in almost any padi field or carp pond, is hard to say. Perhaps the origin of the buffalo manure might have explained it, but there are no records of this. A bloom of *Euglena flava* Dangeard is quite different from the brick-red blooms of *Euglena sanguinea* Ehrenberg, being much more orange in colour. Chu (1946) has suggested that *Euglena flava* Dangeard is synonymous with *Euglena caudata* Hucbner, which he found produced haematochrome in culture, but neither in Dangeard's original description, nor in the Malayan material of *Euglena flava* was there any sign of lobing in the chloroplast as in *Euglena caudata*.

4. ***Euglena gracilis* Klebs.** CELLS nearly cylindrical, $45-55\mu$ long $\times 8-12\mu$ wide, rounded at the anterior end and bluntly pointed at the posterior end, although the tail may round off under pressure from the cover slip. PERIPLAST with such faint striations as to be hardly visible, even under oil immersion. CHROMATOPHORES 7–10 parietal yellowish-green circular to ovoid discs, but the outlines may become irregular when they are closely packed together. PYRENOIDS one in each chromatophore, with a paramylum cup on each side; additional paramylum ovoid bodies which may become so abundant as to bulge out the periplast. FLAGELLUM half to body length, very

active. EYESPOT crimson, prominent. The cell is very active, swimming rapidly by a zig-zag motion which is characteristic, and it can be very metabolic. (Pl. I figs. e, f).

MALAYA: Malacca—fish-ponds.

Selangor—Sungai Gombak, Kuala Lumpur.

Negri Sembilan—standing pools, Port Dickson.

Worldwide in distribution.

This species is easily recognised by its clear yellow-green colour and its characteristic zig-zag swimming motion. It does not appear to be abundant in any sample of water collected, although it is probably wide-spread in distribution. Nevertheless it is probably the easiest species to culture, being tolerant of the acid conditions that often develop in cultures. Cultures of material from different sources often show slight differences in the physiology of the organism and in two cultures at Batu Berendam the cells have shown a tendency to secrete haematochrome, although never in the quantity to be found in the typical red species of *Euglena*.

5. ***Euglena intermedia* (Klebs) Schmitz var. *klebsii* Lemmermann.** CELLS cylindrical 100–130 μ long \times 15–18 μ wide, only slightly narrowing to the blunt anterior end, and narrowing at the posterior end to a short blunt tail piece. PERIPLAST apparently unstriated, even under oil-immersion. The CYTOPLASM is granular and contains spherical bodies which stain with neutral red, scattered throughout the cell except at the ends, where they tend to be clumped. CHROMATOPHORES numerous, lenticular, 8–10 μ long, without pyrenoids. PARAMYLUm in short rods 2 in length, each with a slight central depression. EYE-SPOT purplish red, conspicuous. FLAGELLUM rarely seen, less than one-sixth body length, the cell usually moving by means of a squirming motion. (Pl. I fig. a).

MALAYA: Selangor—Kuala Lumpur, a pond.

Negri Sembilan—Seremban and Port Dickson, stagnant water.

Malacca—stagnant water.

Johore—Muar and Yong Peng, stagnant water.

Singapore—stagnant pools.

A very characteristic species, particular with its squirming habit. The Malayan forms belong to the var. *klebsii* Lemmermann because of the small paramylum rods. The species and its varieties could be confused with *Euglena deses* Ehrenberg, and the type was originally referred to that species as var. *intermedia* Klebs. However *Euglena intermedia* and its forms, including the Malayan material here described, have no pyrenoids as in *Euglena deses*.

6. **Euglena mutabilis** Schmitz [Syn. *Euglena acus* Ehrenberg var. *mutabilis* Klebs.] CELLS cylindrical, $80-110\mu$ long \times $5-9\mu$ wide, tapering very slightly to the blunt, often slightly oblique anterior end and tapering to a point at the posterior end. The PERIPLAST shows faint, steeply spiralling striae which are visible with difficulty. The CYTOPLASM contains numerous small spherical granules visible without staining and scattered throughout the cell. CHROMATOPHORES yellowish-green, usually four parietal plates, two on each side of the nucleus; they are so closely appressed to each other and stretch nearly round the cell that the division between them is difficult to see, but will show up in certain positions of the cell, particularly after staining. PYRENOIDS one in each chromatophore, usually central and showing up as a bulge in edge view. PARAMYLUm short rectangular bodies about 2μ long and often so abundant as to fill the cell. FLAGELLUM not seen in any of the Malayan material examined, the cell being only slightly metabolic and moving by a sideways lashing movement or looping from end to end; eyespot crimson, prominent. (Pl. I figs. b, c, d).

MALAYA: Negeri Sembilan—ditches at Seremban and Port Dickson.

Malacca—ditches at Batu Berendam and elsewhere.

Singapore—ditches near the Royal Island Club golf course and Peirce reservoir.

Distribution worldwide.

LEPOCINCLIS Perty 1852

7. **Lepocinclus fusiformis** (Carter) Lemmermann (emend Conrad) [syn. *Euglena fusiformis* Carter, *Lepocinclus fusiformis* Lemmermann, *Lepocinclus sphagnophila* Lemmermann partem]. CELLS broadly fusiform, $50-60\mu$ long \times $25-30\mu$ wide, slightly truncate at the anterior end, rounded acute at the posterior end. PERIPLAST with distinct striations spiralling backwards from left to right. CHROMATOPHORES numerous, discoid, parietal, each with a simple pyrenoid. PARAMYLUm in the form of two large rings lying just inside the pellicle. FLAGELLUM about $1\frac{1}{2}$ times body length. EYESPOT crimson, anterior. (Pl. I fig. 1).

MALAYA: Singapore in a stagnant pool.

Worldwide in distribution.

PHACUS Dujardin 1841

8. **Phacus meson** Pochmann [syn. ? *Phacus pleuronectes* (O. F. Mueller) Dujardin after Dangeard, *Phacus longicauda* (Ehrenberg) Dujardin var. *brevicaudata* Skvortzow, *Phacus longicauda* var. *indica* Skvortzow]. CELL oval, $75-80\mu$ long without tail

$\times 50\mu$ wide, rounded at the anterior end and tapering posteriorly to a short, stout, straight, pointed tailpiece about 30μ long. PERIPLAST distinctly striated longitudinally CHROMATOPHORES numerous, discoid. PARAMYLUM two large rings. FLAGELLUM about body length. EYESPOT crimson, small. (Pl. I. fig. n).

MALAYA: Fish-ponds in Malacca.

Reported from various parts of S.E. Asia and possibly from Europe.

This form resembles *Phacus longicauda* (Ehrenberg) Dujardin in some respects, but differs in the much shorter, stouter, straight tailpiece and the more oval shape of the body of the cell.

TRACHELOMONAS Ehrenberg 1833 emend Délandre 1926

9. **Trachelomonas allia** Drezepolski forma. This form differs from the type in being distinctly broader at the posterior end, tapering gently to the rounded anterior end. As there are intermediate forms there is no reason to separate the present one as a distinct variety. (Pl. I fig. q).

MALAYA: Fish-ponds in Malacca.

10. **Trachelomonas intermedia** Dangcard. CELL subspherical to elliptic, $18-20\mu$ long $\times 15-17\mu$ wide. LORICA golden brown, finely but distinctly punctate. PORUS with a ring of thickening. CHROMATOPHORES several, discoid. EYESPOT crimson, clearly visible. FLAGELLUM $1\frac{1}{2}-2$ times body length. (Pl. I fig. j).

MALAYA: A ditch in Malacca.

Widespread throughout the world.

11. **Trachelomonas volvocinopsis** Swirenko [syn. *Trachelomonas indica* Skvortzow]. CELL spherical, 15μ in diameter. LORICA smooth, brown without thickening to the porus. CHROMATOPHORES 8-10, discoid, without pyrenoids. EYESPOT red. FLAGELLUM 2-3 times body length. (Pl. I fig. o).

MALAYA: Selangor—standing water at Kuala Lumpur.

Negri Sembilan—standing water at Port Dickson and Seremban.

Malacca—fish-ponds and ditches.

Johore—standing water at Muar.

Singapore—standing water near the reservoirs and the Royal Island Club golf course.

This species might be confused with *Trachelomonas volvocina* Ehrenberg, from which it differs by having more than two chromatophores and by completely lacking pyrenoids.

STROMBOMONAS Déflandre 1930

12. **Strombomonas verrucosa** (Daday) Déflandre var. *chinensis* (Skvortzow) Déflandre [syn. *Trachelomonas chinensis* Skvortzow and vars. *ovata* Skvortzow and *assuriensis* Skvortzow, *Trachelomonas conspersa* Pascher emend. Gordon]. CELL ovoid, 28–30 μ long \times 22–25 μ wide, truncate at the anterior end with a very short wide neck, subconical at the posterior end. LORICA brown, thick and irregularly granular or verrucose on the surface. CHROMATOPHORES numerous discoid. EYE-SPOT crimson, clearly visible. FLAGELLUM about 1½ times body length. (Pl. I fig. p).

MALAYA: Fish-ponds in Malacca.

Described from China and Russia.

Peranemaceae

Cells metabolic or rigid, often crawling, but also free-swimming, usually bilaterally asymmetrical, and dorsiventrally organised. Flagella 1–2 or sometimes absent. Vacuolar system as in *Euglena*, but usually with two rod-shaped bodies, or a tubular siphon the former closely associated with the reservoir. Storage material paramylum granules and sometimes fat. The cells are complete without a stigma or chloroplasts, although occasionally partly digested chloroplast material may be seen inside the cell. Nutrition usually holozoic.

PERANEMA Dujardin 1841

13. **Peranema inflexum** Skuja. CELL cylindrical fusiform, 30–40 μ long \times 9–12 μ wide, narrowed at the anterior end, bluntly rounded at the posterior end, the whole cell usually slightly bent or curved laterally. PERIPLAST with distinct striations spiralling backwards from left to right. RESERVOIR and canal about ¼ body length with an associated rod-shaped organ ("staborgan"). PARAMYLUm as small oval bodies scattered throughout the cell. FLAGELLUM about body length. (Pl. 1 fig. m).

MALAYA: A swamp in Kuala Lumpur.

Described from Northern Europe.

Rhizaspidaceae Skuja

A single genus **Rhizaspis** Skuja

RHIZASPIS Skuja 1948

Cells without flagella, elliptic to ovate, slightly narrowed at the anterior end, rounded to sub-cuneate at the posterior end, markedly flattened dorsiventrally, dorsal side convex, the ventral side concave to slightly convex and often with a slight furrow in it. Periplast smooth, colourless, firm except at the anterior end where fine pseudopodia arise. Siphon or accessory rod-shaped organs ("stab-organs") absent, but there are several vacuoles at the anterior end. The cytoplasm is colourless, with numerous spherical granules of paramylum and sometimes 1-2 large refractive bodies which are probably composed of leucosin.

This is a curious genus, very animal like in nature and nutrition. On the other hand it shows distinct affinities with the Euglenineae in the storage of paramylum, the colourless cytoplasm and the firm periplast.

14. **Rhizaspis granulata** Skuja. CELLS broadly elliptic to ovate, $60-65\mu$ long \times $40-45\mu$ wide \times $18-20\mu$ thick; at the narrowed anterior end it is slightly protruded to form a rounded lip-like structure, from which fine pseudopodia arise, at the posterior end it is broadly cuneate; in side view the cell is curved with a truncate anterior end and cuncate posterior end, the ventral side concave with a broad shallow longitudinal furrow, the dorsal side convex. PERIPLAST colourless, smooth and quite firm. CYTOPLASM colourless, with several vacuoles at the anterior end, numerous PARAMYLM granules at the posterior end, several food granules, and sometimes 1 large refractive granule of leucosin, although this is not always present. NUCLEUS large, subcentral. The cell moves by crawling over the substratum by means of the pseudopodia, with the cell body erect, or more usually held at an oblique angle. (Pl. II figs. c, d).

MALAYA: Experimental fish-ponds in Malacca.

Described from Northern Europe.

There is no doubt about the identity of the Malayan specimens. They agree with Skuja's description except in the number of leucosin granules, for here they are often absent.

15. **Rhizaspis simplex** Skuja. CELLS oval, $50-55\mu$ long \times $30-35\mu$ wide \times $20-22\mu$ thick, rounded at the posterior end, narrowed to the truncate anterior end, from which fine pseudopodia arise, but without a lip-like protrusion; in side view the cell convex on the dorsal side, less so on the ventral side; sometimes

there are two low broadly rounded ridges on the dorsal side, and a shallow furrow on the ventral side, but these are not always very visible since the cell is a little metabolic and can swell out its outlines. PERIPLAST colourless, smooth, firm but elastic. CYTOPLASM colourless with several vacuoles at the anterior end and numerous spherical granules of PARAMYLUM at the posterior end, and often several food granules. Leucosin appears to be absent. NUCLEUS large, sub-central. The cell crawls along by means of the pseudopodia, keeping the body erect, but occasionally this latter will shorten and fatten slightly. (Pl. II figs. a, b).

MALAYA: Experimental fish-ponds in Malacca.

Described from Northern Europe.

The truncate anterior end places the Malayan forms under this species, but they are a little fatter than the forms described by Skuja, and the ridges and furrows are not always so easy to see.

CHLOROMONADINEAE

A class of flagellates with only a few forms known, and of which the affinities are very uncertain. No coccoid or filamentous forms have been recorded, all known forms being motile unicells, usually oval or pyriform in shape. The cell is often dorsiventrally flattened, with a ventral furrow. There are two flagella, one usually trailing, and they are attached near the aperture of a complex vacuolar system recalling that in the Euglenineae. In the pigmented forms there are numerous discoid chloroplasts, bright green in colour, but containing an excess of xanthophyll—they give a blue colour with concentrated hydrochloric acid, and in this respect the group resembles the Xanthophyceae. Neither starch nor paramylum occur, food reserves being fats and oils. In many forms radially disposed trichocysts are found in the peripheral regions, often more crowded at the anterior end, and these may be discharged on stimulus. Reproduction, as far as is known, is by longitudinal fission. This class forms a somewhat isolated group, but resembles the Euglenineae in the vacuolar system, but differs in the nature of the pigments and food reserves, in which respect it shows closer resemblance to the Xanthophyceae.

Two genera recorded from Malaya:—

1. Cells green, with trichocysts. Flagella apically attached
Gonyostomum.
2. Cells green, with trichocysts. Flagella laterally attached
Merotrichia.

GONYOSTOMUM Diesing 1866

Cells motile, dorsiventrally flattened, obovate, to spherical in front view, slightly metabolic, often narrowed posteriorly. Dorsal surface convex, ventral surface flattened, with a shallow furrow leading from the opening of the vacuolar system ("pharynx") and running longitudinally. Vacuolar system a triangular "pharynx"—like structure. Chromatophores numerous, discoid, green. Eyespot absent. Nucleus central. Trichocysts radial, abundant, more closely packed at the anterior end. Flagella two, one trailing but both attached at the mouth of the "pharynx". Oil and fat droplets occur as the food reserve.

16. **Gonyostomum depressum** Lemmermann [syn. *Vacuolaria depressa* Lauterborn]. CELL round in face view, $30-40\mu$ in diameter, broad elliptic in side view, about $25-30\mu$ thick. CHROMATOPHORES numerous, green, discoid, lining the periphery of the cell. VACUOLAR SYSTEM a small triangular "pharynx". TRICHOCYSTS numerous, peripheral, radial, but crowded at the anterior end. FLAGELLA two, distinctly unequal in length. Storage material oil and fat droplets. (Pl. II fig. o).

MALAYA: Malacca—in acid swamps.

Described from Europe.

This species resembles *Gonyostomum latum* Iwanoff, but differs in the unequal flagella.

17. **Gonyostomun semen** Diesing [syn. *Rhaphidomonas semen* Ehrenberg]. CELL elongate-obovate, $40-70\mu$ long $\times 22-40\mu$ wide, rounded at the anterior end and narrowed to a subcuneate posterior end, very much flattened dorsiventrally, about $10-15\mu$ thick, and with a broad ventral furrow. CHROMATOPHORES numerous, green, discoid, lining the periphery of the cell. VACUOLAR SYSTEM a prominent apical, triangular "pharynx". TRICHOCYSTS numerous, peripheral, radial, but very crowded at the anterior end. FLAGELLA two, nearly equal, but one trailing, both about body length. Storage material fat and oil. (Pl. II fig. g).

MALAYA: Malacca—in acid swamps.

Worldwide in distribution.

MEROTRICHIA Mereschkowski 1877

Cells ellipsoidal to bean shaped, sometimes slightly metabolic, rounded at the anterior end, occasionally slightly narrowed towards the posterior end. Vacuolar system a rounded "pharynx" like structure, laterally placed towards the anterior end. Chromatophores numerous, green discoid. Eyespot absent. Nucleus central.

Trichocysts scattered except at the anterior end, where they are crowded. Flagella two (one only described for *Merotrichia bacillata* Mereschkowski, but a second one is probably present), unequal, attached laterally at the mouth of the pharynx. Food reserves consists of oil and fat droplets. One species reported in Malaya.

18. ***Mero*trichia capitata** Skuja. CELLS oval to bean-shaped, $30-40\mu$ long \times $22-25\mu$ wide, rounded at the anterior end and narrowed towards the posterior end, but sometimes slightly metabolic; just below the anterior end is a lateral cleft indicating a pharynx and the cell is often curved towards that side. CHROMATOPHORES numerous, green, discoid, lining the periphery of the cell, VACUOLAR SYSTEM a laterally placed "pharynx" with a groove leading into it. TRICHOCYSTS crowded at the anterior end, few and scattered elsewhere. FLAGELLA two, the swimming one about $\frac{1}{3}$ body length and pointing forward, the other longer $1-1\frac{1}{2}$ body length, trailing. Storage material fat and oil. (Pl. II. fig. h).

MALAYA: Malacca—in acid swamps.

Described from Northern Europe.

CRYPTOPHYCEAE

Cells usually motile by means of two apical or lateral flagella, although a few coccoid forms have been placed in this group. The cells are dorsiventrally flattened, oval, slipper-shaped or reniform, and possess a longitudinal furrow. In many forms a gullet extends inwards from the anterior end of the furrow. Chromatophores usually 2, occasionally many, sometimes one or absent, the pigments varying from golden-brown, red, to distinctly blue. Pyrenoids occur, apparently not embedded in the chromatophores, and occasionally they may be absent. Storage products starch or allied carbohydrates, and sometimes oil as well. In some forms trichocysts may occur closely surrounding the gullet. Reproduction is usually by longitudinal division, although palmelloid stages may be formed first.

Three genera have been found in Malaya:—

1. Cells pigmented, slipper shaped, with two flagella which are attached slightly to one side of the apex

Cryptomonas.

2. Cells as above but without chromatophores *Chilomonas*.
3. Cells pigmented, reniform, with the two flagella attached at the middle of the concave margin *Sennia*.

CRYPTOMONAS Ehrenberg 1838

Cells slipper-shaped, dorsiventrally flattened, convex on the dorsal surface, flat or concave ventrally, with a broad longitudinal furrow from which a gullet extends inwardly from the anterior end. Flagella two, attached at the opening of the gullet. Chromatophores 1 or 2, lateral and parietal. Storage products starch grains. Trichocysts often visible round the gullet. There are 1-3 contractile vacuoles. Stigma apparently absent.

19. **Cryptomonas erosa.** Ehrenberg var. *reflexa* Marsson. CELLS slipper-shaped, $20-30\mu$ long $\times 10-15\mu$ wide, obliquely truncate at the anterior end, narrowed posteriorly to a blunt point which is turned to one side, so that the whole cell is slightly sigmoid. CHROMATOPHORES two, lateral, golden brown to yellowish green in colour. PYRENOIDS absent. STORAGE PRODUCTS oval to polygonal starch grains lining the inner sides of the chromatophores. FLAGELLA two, slightly unequal, the longer being a little more than body length, the other a little less, both inserted at the mouth of the gullet in the middle of the oblique anterior end. (Pl. II. figs. k, l, n).

MALAYA: Malacca—in experimental fish-ponds.

Worldwide in distribution.

This is very similar to *Cryptomonas marssonii* Skuja, which has been separated off for reasons which are not very obvious, in particular the more sharply truncate anterior end and the more depressed mouth of the gullet.

20. **Cryptomonas ovata** Ehrenberg. CELLS almost ellipsoidal, $45-50\mu$ long $\times 18-25\mu$ wide, slightly obliquely truncate at the anterior end, rounded at the posterior end, the whole cell curved slightly to one side. CHROMATOPHORES two, lateral, large, nearly filling the periphery of the cell but with the division between them quite clear, golden brown to yellowish green in colour, often appearing netted where the closely packed starch grains press against them. PYRENOIDS absent. STORAGE PRODUCTS starch grains, usually oval but appearing polygonal when tightly packed, lining the inner sides of the chromatophores. GULLET prominent, stretching $1/3-\frac{1}{2}$ length of the cell, and surrounded by trichocysts. FLAGELLA two, nearly equal, a little less than body length. (Pl. II fig. m).

MALAYA: Malacca—in small experimental fish-pond.

Worldwide in distribution.

21. **Cryptomonas phaseolus** Skuja. CELLS small, elliptic, $12-15\mu$ long $\times 8-9\mu$ wide, rounded at both ends and only very slightly oblique at the anterior end. CHROMATOPHORES two, lateral, brownish in colour. PYRENOIDS absent. STORAGE PRODUCTS several comparatively large oval starch granules lining

the inner side of the chromatophores; occasionally 1–2 central, oval refractive bodies. GULLET about $1/3$ – $\frac{1}{2}$ body length, with the opening at one side of the apex. FLAGELLA two slightly unequal in length, a little shorter than body length. (Pl. II figs. i, j).

MALAYA: Malacca—in experimental fish-pond.

Described from Northern Europe.

Skuja describes his specimens as violet brown and thiophile. The Malacca specimens are more golden brown to reddish brown, but they may well be thiophile, since the pond in which they were found had a slight smell of hydrogen sulphide.

CHILOMONAS Ehrenberg 1838

Cells resembling *Cryptomonas* but completely devoid of chromatophores and pyrenoids. Cells more or less slipper-shaped, dorsiventrally flattened, the opening of the gullet somewhat sunken so that the surrounding margin has a lip-like appearance. One lateral margin is distinctly more convex than the other, which may be flattened. Trichocysts often surrounded the gullet, and storage products are comparatively large starch granules. Flagella two, unequal, attached at the mouth of the gullet.

Usually found in polluted water, often in abundance.

22. *Chilomonas paramecium* Ehrenberg. CELLS slipper-shaped. $25\text{--}30\mu$ long $\times 10\text{--}15\mu$ wide, rounded at the posterior end, lip-like at the anterior end, with a lateral kink indicating the sunken opening of the gullet; lateral margin adjacent to the gullet only slightly convex or even flattened, the other margin distinctly convex. CHROMATOPHORES absent. PYRENOIDS absent. GULLET prominent, about half the length of the cell, surrounded by trichocysts. STORAGE PRODUCTS large round starch granules. FLAGELLA two, unequal, the longer being about body length. (Pl. II fig. f).

MALAYA: Selangor—polluted water from the Gombak river, Kuala Lumpur.

Worldwide in distribution.

SENNIA Pascher 1913 emend. Skuja 1948

Cells bean-shaped, dorsiventrally flattened and one lateral margin decidedly convex, the other slightly concave with an equatorial groove running from it. Gullet in the middle of the concave side, not very prominent. Trichocysts apparently absent. 1–2 contractile vacuoles occur near the gullet. Chromatophores 1–2, golden yellow to olive-green in colour. Pyrenoids present or absent. Eyespot present or absent. Flagella two, unequal in length, laterally attached at the opening of the gullet.

23. **Sennia parvula** Skuja. CELLS small, bean-shaped, 10μ long $\times 5\mu$ wide, very convex on one lateral margin, flattened or slightly concave on the other. CHROMATOPHORE one, curving round the convex margin, olive-green in colour. STIGMA absent in the Malayan specimens. PYRENOIDS absent. GULLET small, in the middle of the concave margin, without trichocysts but with a single small contractile vacuole. FLAGELLA two, divergent, unequal in length, the longer about body length. (Pl. II fig. e).

MALAYA: Malacca—in an experimental fish-pond.

Reported from Northern Europe, America and Africa.

The Malayan specimens differ from the type only in the absence of the stigma, a varying feature in this genus anyway.

CHRYSTOPHYCEAE

The Chrysophyceae are characterised by possessing chromatophores which are golden-yellow to brown in colour, although in waters rich in organic matter they may assume a greenish tint. The main pigment giving the golden-yellow colour is *phycocochrysin*, but modified chlorophylls and xanthophylls may also occur. Storage products consist of oil and whitish, highly refractive, usually round lumps, leucosin, often forming a prominent mass in the posterior portion of the cell. Leucosin appears to be a carbohydrate, although some doubt has been thrown on this, and it is readily soluble in most reagents and dots not react with iodine. Starch is never formed.

All Chrysophyceae appear to be uninucleate and may range from simple motile flagellate cells, and motile colonies to branched palmelloid forms or even a few filamentous species. A characteristic feature of the class is the formation endogenously of cysts, the walls of which are impregnated with silica.

The Chrysophyceae are frequently grouped together with the Xanthophyceae and Bacillariophyceae in the phylum Chrysophyta. In addition to the absence of chlorophyll b in all three classes, and the absence of starch, there are certain other structural similarities. In both the Xanthophyceae and Chrysophyceae endogenously formed cysts have been reported. These are frequently impregnated with silica, an obvious comparison with the Bacillariophyceae. The cell envelope of some Chrysophyceae (*Hyalobryon*) is laminated, recalling similar conditions in the Xanthophyceae (*Ophiocytium*) and even the intercalary bands in the Diatoms. Leucosin has been reported in certain Diatoms.

KEY TO THE ORDERS OF THE CHRYSOPHYCEAE

1. Cells normally motile and flagellate, sometimes amoeboid.
Colonial forms motile **CHRYSOMONADALES.**
2. Cells normally amoeboid, holozoic, flagellate stages rare or absent [**RHIZOCHRYSIDALES**].
3. Cells in palmelloid colonies, often elaborately branched
[**CHRYSOCAPSIDALES**].
4. Cells coccoid, flagellate stages rare or absent
[**CHRYSOPHAERALES**].
5. Plants filamentous [**CHRYSOTRICHALES**].

KEY TO THE CHRYSOMONADALES

1. Cells with 1 flagellum **CHROMULINEAE.**
2. Cells with 2 equal flagella **ISOCHRYSIDEAE.**
3. Cells with 2 unequal flagella **OCHROMONADEAE.**
4. Cells with 3 flagella, one short and two long
[**PRYMNESEAE**].

CHROMULINEAE

- (i) Cells naked (ii).
- (i) Cells not naked, possessing a wall or envelope (iii).
 - (ii) Cells only rarely amoeboid, usually flagellate ... *Chromulina*.
 - (ii) Cells markedly amoeboid, with prominent pseudopodia
Chrysamoeba.
- (iii) Cells with small lens-shaped siliceous scales embedded in the wall, without regular arrangement and devoid of spines
(*Microglena*).
- (iii) Cells with much larger siliceous scales, regularly arranged and frequently bearing long spines *Mallomonas*.
- (iii) Cells with siliceous material in complete transverse bands
(*Conradiella*).
- (iii) Cells enclosed in a stalked envelope *Chrysopyxis*.
- (iii) Cells in spherical colonies, set with long needles
(*Chrysosphaerella*).

CHROMULINA Cienkowsky 1870

Cells naked, ovoid pyriform, elliptic or spherical unicells, often very metabolic and each bearing a single apical flagellum. Periplast of the cell often granular or set with small wart-like excrescences. Chromatophores 1-2, clearly differentiated, curved plate or rings, sometimes nearly filling the periphery of the cell, in most cases without pyrenoids. In many species there is a stigma. At the anterior end there are 1-2, sometimes more, contractile vacuoles. Storage products leucosin, often as a large single sphere at the posterior end of the cell, and oil droplets. The cysts are formed endogenously, with the wall impregnated with silica and are spherical with a symmetrically placed mouth, which may or may not bear a prominent neck.

24. **Chromulina sphaerica** Bachman. CELLS spherical, $12-15\mu$ in diameter. PERIPLAST smooth, not granular nor with excrescences. CHROMATOPHORE a single laged curved plate lying against the periplast but varying in position, without a pyrenoid. STIGMA present, small crimson but conspicuous. FLAGELLUM $1-1\frac{1}{2}$ body length. (Pl. V fig. g).

MALAYA: Malacca—in fish-ponds.

Described from Europe.

Bachman describes his species with the chromatophore in the middle, whereas here it lines the periphery. It is therefore possible that the Malayan forms should be regarded as a separate species, although it is difficult to decide how much importance should be given to the position of the chromatophore. In all other respects the Malayan forms agree with Bachman's description.

CHRYSAMOEBA Klebs. 1893

Cells motile with a single apical flagellum, often bearing fine pseudopodia whilst still flagellate, occasionally losing the flagellum. Chromatophores 1-2 curved plates or bands, central or parietal. Stigma present or absent. Pyrenoids present or absent. Cysts, where known, spherical with a centrally placed orifice. Leucosin granule often present as storage material.

25. **Chrysamoeba radians** Klebs. FLAGELLATE STAGE ovoid, $15-25\mu$ long \times $8-12\mu$ wide, often narrowed at the posterior end. CHROMATOPHORE usually 1, bandshaped curving round the cell even in amoeboid stages, occasionally two, without PYRENOIDS. STIGMA absent. FLAGELLUM $1-1\frac{1}{2}$ body length rarely shorter. CYST spherical, $20-22\mu$ in diameter, with a short tapering neck. (Pl. V fig. i, j, k, l).

MALAYA: Malacca—in fish-ponds.

Worldwide in distribution.

The Malayan forms are larger than most records for this species, and the chromatophore is appreciably larger and curves just inside the periplast rather than being central. For this reason they might be regarded as a separate species. On the other hand they were collected from very fertile ponds in a region of high light intensity. It is possible that in less fertile waters and with lower light intensities the chromatophores may be smaller and contract to the middle of the cell.

MALLOMONAS Perty 1852

Cells solitary, motile by means of a single flagellum, ovoid, ellipsoid, cylindrical, spherical or pyriform in shape; periplast with numerous circular, discoid or angular silicified imbricating scales; scales usually regularly arranged, often in spirals, rarely truly irregular, often bearing long siliceous spines or setae which may be toothed, occasionally shorter ones or completely lacking; chromatophores golden-yellow, 2, lateral and parietal; contractile vacuoles present at the anterior end of the cell; eyespot often lacking; nucleus ellipsoid, often large and distinct; storage material leucosin, as large spherical granules at the posterior end.

26. **Mallomonas acaroides** Perty. CELLS ovoid to ellipsoid, 30– 50μ long \times 15–22 μ wide, rounded posteriorly and often slightly narrowed at the anterior end. SCALES oval to elliptic, arranged in spiral rows. SETAE long, somewhat curved, one to each scale so that the whole cell is covered by spines. CHROMATOPHORES 2, large, lateral and parietal, golden-yellow in colour. FLAGELLUM about body length. (Pl. III figs. e, f, l).

MALAYA: Malacca—in experimental fish-ponds.

Distribution worldwide.

This is a characteristic if somewhat variable species. The Malayan forms are larger than most of those recorded from elsewhere, but, not sufficiently so to warrant any separation as a variety.

27. **Mallomonas curta** (Playfair) Conrad. [syn. *Mallomonas litomesa* Stokes var. *curta*, Playfair]. CELLS elliptic 18–30 μ long \times 11–15 μ wide, with a very short broad papillum at the anterior end, rounded at the posterior end. SCALES circular, arranged in shallow spirals. SETAE six only, about $\frac{1}{3}$ body length, attached at the papillum and curving backwards. FLAGELLUM about body length. STIGMA small, crimson but often lacking. (Pl. III figs. g, i).

MALAYA: Malacca—in swamp.

Described from Australia and reported from Europe.

28. **Mallomonas playfairii** Conrad var. **opisthiodonta** Prowse. var. nov. CELLS ellipsoid, $19-20\mu$ \times $14-15\mu$ wide, broadly rounded at both ends, but terminating anteriorly in a very short neck. SCALES rhombic, spirally arranged at an angle 45° , without spines except in the four rearmost scales, which each bear a single short spine. CHROMATOPHORES two, large, parietal. FLAGELLUM nearly body length. (Pl. III fig. j).

MALAYA: Malacca—fish-ponds. (Type locality).

HOLOTYPE: Prowse 398 deposited at Tropical Fish Culture Research Institute, Malacca.

Cellulae ellipsoideae, $19-20\mu$ longae, $14-15\mu$ latae, utrinque late-rotundatae, unaquaeque antice in collum brevissimum terminata. *Squamae* rhombicae, ad angulum 45° spiraliter dispositae, spiris longissimis carentes, sed quattuor squamae postremae tantum brevissime unispinosae. *Flagellum* corpori paene aequilongum aequilongum. *Chromatophora* duo, magna, parietalia.

MALAYA: Malacca—in stagnis piscosis. (Holotypus).

29. **Mallomonas spherica** Prowse sp. nov. CELLS spherical, $8-9\mu$ in diameter. SCALES elliptic, arranged spirally at a slight angle, only the anterior-most scales being spiny; SETAE 9–10 in all, 2– $2\frac{1}{2}$ times longer than the body, strongly reflexed. CHROMATOPHORES 2, discoid, parietal. FLAGELLUM nearly as long as the body. (Pl. III fig. m).

MALAYA: Malacca—in fish-ponds. (Type locality).

HOLOTYPE: Prowse 395 deposited at Tropical Fish Culture Research Institute, Malacca.

Cellulae sphaericae, $8-9\mu$ in diam. *Squamae* ellipticae, ad angulum paululum spiraliter dispositae, eae antice sitae tantum spinasae; spinis 9–10, quam corpus 2– $2\frac{1}{2}$ -plo longioribus, valide reflexis. *Flagellum* corpori paene aequilongum. *Chromatophora* duo, discoida, parietalia.

MALAYA: Malacca—in stagnis piscosis. (Holotypus).

30. **Mallomonas splendens** (G. S. West) Playfair [syn. *Lagerheimia splendens* G. S. West]. CELLS cylindrical, $30-50\mu$ long \times $15-17\mu$ wide, slightly narrowed at each end to the rounded poles. SCALES nearly rhombic, finely punctate and spirally arranged. SETAE confined to the poles, 4 at each end, about $\frac{1}{2}$ body length, divergent. CHROMATOPHORE one, large, lining one side. FLAGELLUM about $\frac{1}{2}$ body length. (Pl. III fig. c).

MALAYA: Selangor—acid swamp in Kuala Lumpur.

Negri Sembilan—acid swamps at Port Dickson and Seremban.

Malacca—acid swamps in various areas.

Singapore—swampy pools near the Royal Island Club golf course and Peirce reservoir.

Worldwide in distribution, including Indonesia.

A very characteristic species.

31. **Mallomonas teilingioides** Prowse sp. nov. CELLS elongate-elliptic, 50–55 μ long, 18–20 μ wide, equally rounded at both ends, or slightly narrower at the anterior end. SCALES distinctly quadrate, spirally arranged, only the ones near the poles bearing setae, the others apparently smooth 5–9 in the largest spirals (median ones). SETAE slender, simple, 15–20 at each end of the cell, 30–32 μ long. CHROMATOPHORES two, large, parietal, golden yellow. STIGMA prominent, crimson, at the anterior end. FLAGELLUM $\frac{1}{2}$ body length. LEUCOSIN a large single grain at the posterior end. (Pl. III figs. d, k).

Superficially resembling *Mallomonas teilingii* (Teiling) Conrad, from which it differs in scales being quadrate (not discoid) and in having slightly more numerous setae.

MALAYA: Malacca—in fish-ponds. (Type locality).

HOLOTYPE: Prowse 414a deposited at Tropical Fish Culture Research Institute, Malacca.

Superficialiter *Mallomonas teilingii* (Teiling) Conrad similis, a qua squamis quadratis, non discoideis, et setis paulo numerosioribus differt.

Cellulae elongato-ellipticae, 50–55 μ longae, 18–20 μ latae, utrinque pariter rotundatae vel apice anteriori angustiusculae. *Squamae* conspicue quadratae, spiraliter dispositae, apicales tantum setosae, alterae apparerent leves, in singulis spiris maximis 5–9. *Setae* graciles simplices, utraque cellulae apice 15–20 sitae, 30–32 μ longae. Flagellum longitudine semi-cellulare. Chromatophora dua, magna, parietalia, fulva; ocellum prominens, coccineum, prope apicem anteriorem situm. Leucosin unigranulare, magnum ad extremitatem posteriorem situm.

MALAYA: Malacca—in fossis piscicolis. (Holotypus).

Philipose (1953) has described a species which shows some resemblances to the present one, but he was not able to determine the exact nature of the scales. He suggests that they were discoid and circular, and this fact and his report of fewer setae at the anterior end, suggests that he was dealing with a different species.

32. **Mallomonas tonsurata** Teiling var. **alpina** (Pascher) Krieger. [syn. *Mallomonas alpina* Pascher, *Mallomonas tonsurata* var. *megalipsis* Schiller]. CELLS small, ovoid, 15–20 μ long \times 10–12 μ wide, rounded at the posterior end, narrowing at the anterior end. SCALES small, elliptic, with a V-shaped mark on the

base of each, and arranged in very shallow spirals. SETAE confined to the anterior end, usually in three rows of six, comparatively stout, toothed, longer than body length. CHROMATOPHORES 2, lateral and parietal, golden-yellow. STIGMA small, crimson, situated at the anterior end. FLAGELLUM about body length. (Pl. III figs. a, b).

MALAYA: Malacca—in fish-ponds.

Described from Europe, but reported also from Java.

This variety differs from the type mainly in its smaller size and the toothed setae.

33. *Mallomonas tonsurata* Teiling var. *dorsidentata* Prowse var. nov. Cells elongate-ovoid, $23-25\mu$ long \times $8-9\mu$ wide, slightly narrowed at the anterior end. SCALES small, elliptic, arranged at a slightly acute angle, the rearmost scales very shortly unidentate. SETAE very long, 20–30 in number, confined to the anterior half of the cell, the apical ones 15μ long, shorter than the infra-apical ones which are 20μ long. CHROMATOPHORES two large, discoid, parietal. FLAGELLUM nearly body length. (Pl. III fig. h).

MALAYA: Malacca—in fish-ponds. (Type locality).

HOLOTYPE: Prowse 406 deposited at Tropical Fish Culture Research Institute, Malacca.

Cellulae elongato-ovoideae, apice antico paulo angustiores, $23-25\mu$ longae, $8-9\mu$ latae. *Squamae* parvae, ellipticae, ad angulum acutiusculum dispositae; squamae postremae brevissime unidentatae. *Setae* longissimae in dimidia cellulae antica circumscriptae, 20–30, eae apicales 15μ longae breviores quam infra-apicales 20μ longae. *Flagellum* corpori fere aequilongum. *Chromatophora* duo, magna, discoidea, parietalia.

MALAYA: Malacca—in stagnis piscosis. (Holotypus).

CHRYSTOPHYXIS Stein 1878

Cells each enclosed in a cellulose envelope which is flask-shaped in face view, with a slender thread like attachment extension at the base; in side view the base is saddle-shaped, sitting on an algal filament, with a thread like attachment extension each side, which may completely surround the filament from one side to the other. Chromatophores one or two, golden yellow, usually parietal. Flagellum one, but often replaced by a slender protoplasmic extension (rhizopodium) which may or may not be slightly branched, in both cases protruding from the orifice of the envelope. Contractile vacuoles occur, apical when a flagellum is present, apparently basal when a rhizopodium is present; in the latter case it seems likely that the cell has inverted within the envelope, so that the rhizopodium arises from the morphologically posterior end of the cell.

34. **Chrysopxis** sp. ENVELOPE flask-shaped, $10-12\mu$ high \times $6-8\mu$ wide, sharply drawn out basally to a fine peduncle, apically tapering to a narrow neck. CELL round, three quarters filling the envelope. CHROMATOPHORES two, parietal, or possibly one, divided deeply into two lobes. 'FLAGELLUM' long, twice body length, probably rhizopodial in nature since it does not arise from the anterior end of the cell, but sometimes from the side and sometimes from the morphological posterior end, the cell lying at all angles in the envelope and may even be inverted. CONTRACTILE VACUOLES variable in position. (Pl. IV fig. e).

MALAYA: Malacca—in fish-ponds.

This shows very great resemblances to *Chrysopxis iwanoffi* Lauterborn, but differs in that the rhizopodium is unbranched and closely resembles a flagellum.

35. **Chrysopxis** sp. ENVELOPE ovoid, $18-20\mu$ long \times $8-10\mu$ wide, narrowing apically to a widish neck, tapering basally to a short peduncle. CELL round, two thirds filling the envelope, slightly flattened anteriorly. CHROMATOPHERE one, large, parietal, curving transversely round the cell. FLAGELLUM one, arising from the anterior end of the cell, $1\frac{1}{2}$ body length. CONTRACTILE VACUOLES two, apical. (Pl. IV fig. f).

MALAYA: Malacca—in fish-ponds.

This species resembles *Chrysopxis urna* Korshikov in the envelope, but differs in retaining the flagellum and in the apical contractile vacuoles.

ISOCHRYSIDEAE

2 equal flagella

1. Cells apparently naked, long stalked, epiphytic
(Stylochrysallis).
2. Cells within an envelope ii.
- ii. Envelope with a prominent orifice, no siliceous scales iii.
- ii. Envelope with siliceous scales, completely surrounding the protoplast v.
- iii. Envelope long stalked (*Stylotheca*).
- iii. Envelope very shortly stalked or sessile (*Derepyxis*).
- iv. Cells in pairs, never more, with broad bases attached to each other *Chrysodidymus*.
- iv. Cells in spherical colonies, attached bases tapering .. *Synura*.
- iv. Cells in bands usually of two rows, basal attachments broad
(Catenochrysis)
= (*Chlorodesmus*).

CHYSODIDYMUS Prowse gen. nov.

Somewhat similar to *Synura*, this genus is readily distinguished by its colonies being always of two cells, wider posteriorly. The motion is forward and backwards in a straight line, occasionally making a turn of 180° and moving on as before, never effecting its movement as in *Synura* by rolling in complete revolutions. Cells trapezoidal in shape, united directly and firmly at the posterior ends to form bicellular colonies, the anterior end free and narrower than the posterior ones. *Involucrum* similar to that in *Synura*, with siliceous, shortly spinose scales. *Flagella* two to each cell, apical, apparently equal in length, in motion one pointing forward, the other trailing behind. *Chromatophores* two, large, discoid and parietal.

Synurae aliquatenus simile sed coloniis nunquam non bicellularibus, protinus vel retrosum recte progredientibus interdum per 180° vertentibus et dein ut supra moventibus, nunquam ut in *Synura* per gyrationes vel circumvolutiones proficientibus, cellulis postice lateoribus hoc genus facile distinguendum.

Cellulae ambitu trapezoideae, apicibus posticis extemplo firmiterque in colonias bicellulares unitae; apicibus anticus liberis quam postices angustioribus; involucrum eo *Synurae* simile, squamis siliceis, spinulosis praeditum. *Flagella* per cellulam singulam bina, apicalia, simulate aequilonga, in motu unum porrectum, alterum a tergo trahens. *Chromatophora* bina, magna, discoidea, parietalia. Species holotypica: *Chrysodidymus synuroideus* Prowse.

36. *Chrysodidymus synuroideus* Prowse sp. nov. CELLS $14-15\mu$ long, posterior end $10-11\mu$ wide, anterior end $7-8\mu$ wide, trapezoid in shape. CHROMATOPHORES, two large, parietal golden yellow. FLAGELLA body length or slightly longer, apparently equal in length. (Pl. IV fig. n.).

MALAYA: Malacca—in acid swamps. (Type locality).

HOLOTYPE: Prowse 248a deposited at Tropical Fish Culture Research Institute, Malacca.

Cellulae ambitu trapezoideae, $14-15\mu$ longae, apicibus posterioribus $10-11\mu$ latis, apicibus anterioribus $7-8\mu$ latis. Chromatophora dua, magna, parietalia, fulva. *Flagella* corpori aequilonga vel paululo longiora, inter se aequilonga ut videtur.

MALAYA: Malacca—in locis paludosis acidis (Holotype).

37. *Chrysodidymus gracilis* Prowse sp. nov. CELLS longer and narrower than those in the preceding species $22-24\mu$ long, posterior end $8.5-9\mu$ wide, anterior end $6-6.5\mu$ wide. FLAGELLA nearly body length. (Pl. IV fig. m).

MALAYA: Malacca—in acid swamps.

HOLOTYPE: Prowse 248b deposited at Tropical Fish Culture Research Institute, Malacca.

Cellulae eis prioris speciei longiores angustioresque, 22–24 μ longae, apicibus posterioribus 8.5–9 μ latis, apicibus anterioribus 6–6.5 μ latis. *Flagella* corpori fere aequilonga.

MALAYA: Malacca in locis paludosis acidis. (Holotypus).

SYNURA Ehrenberg 1838

Cells ovoid, pyriform or clavate, united in spherical to sausage-shaped colonies, with the cells attached to each other by the attenuated posterior ends, even in two-celled colonies, thus differing markedly from *Chrysodidymus* and *Catenochrysis*. Cell membrane bearing siliceous scales which are frequently shortly spinose, one spine to each scale. Chromatophores two, large, parietal, golden yellow in colour. Flagella two to each cell, apparently equal in length, but one projects forwards, the other trailing sideways; the forward projecting flagellum is of the "tinsel" type, with a row of very short cilia, the trailing flagellum being smooth. The colony moves by rolling over and over, revolving through 360° continuously in one direction.

38. *Synura uvella* Ehrenberg. CELLS elongate-ovoid to pyriform, 20–25 μ long \times 12–15 μ wide, broadly rounded at the anterior end, narrowing markedly at the posterior end, often to a thread-like attachment organ. CHROMATOPHORES two, large, parietal, golden yellow. FLAGELLA two, apical, apparently equal, more than body length. COLONIES of few to many cells, spherical to sausage shaped. (Pl. IV figs. d, k, l).

MALAYA: Selangor—in acid swamps near Kuala Lumpur.

Negri Sembilan—in various acid swamps.

Malacca—in acid swamps.

Singapore—in acid swamps near the Royal Island Club golf course.

Probably to be found in all parts of Malaya.

Worldwide in distribution.

OCHROMONADEAE

2 unequal flagella

- (i) Cells without cellulose envelopes, naked ii.
- (i) Cells with cellulose envelopes iii.
- (ii) Cells solitary *Ochromonas*.
- (ii) Cells colonial, usually in spherical colonies (*Uroglena*, *Volvochrysis*, *Synochromonas*, *Synuopsis*).

- (iii) Cells in dendroid colonies, or epiphytic and solitary. Protoplasts stalked inside envelope iv.
- (iii) Cells solitary. Protoplasts not stalked inside envelope (*Pseudokephyrion*, *Kephyriopsis*, *Bitricha*, *Styloceras*).
- (iv) Envelope markedly laminate, with ends of lamina projecting *Hyalobryon*.
- (iv) Envelope not laminate or if lamina present visible with difficulty and not projecting *Dinobryon*.

OCHROMONAS Wyssotzki 1887

Cells usually solitary, naked, free swimming or occasionally attached by a posterior threadlike extension. Shape very variable, occasionally amoeboid. Periplast usually fine and smooth, rarely thick and verrucose. Chromatophores 1–2, golden-yellow, often very much reduced. Flagella two, unequal, the longer one pointing forwards in swimming, the shorter trailing sideways. Palmelloid stages often found.

39. *Ochromonas hinterzartensis* Doflein. CELL elongated ovoid, $14\text{--}15\mu$ long \times $7\text{--}8\mu$ wide, rounded at the posterior end, slightly narrower anteriorly. PERIPLAST beset with peripheral granules, but not verrucose. CHROMATOPHORE single, band-shaped, curving round lower half of cell, golden yellow in colour. STIGMA absent. FLAGELLA two, unequal, the longer body length, the shorter about $1/3$ body length. LEUCOSIN as four large oval granules. (Pl. V fig. h).

MALAYA: Malacca—in fish-ponds.

Described from Northern Europe.

This Malayan form seems to fit best into this species, especially with its peripheral granules and several large leucosin granules. The shorter flagellum is a little longer than that in the holotype as described from Germany, but it is difficult to be accurate in estimates of the lengths of flagella.

DINOBRYON Ehrenberg 1835

(includes *Epipyxis* (Ehrenberg) Lauterborn and *Dinobryopsis* Lemmermann).

Cells free-floating, sessile or epiphytic, solitary or in colonies, each cell enclosed in a conical, campanulate or cylindric cellulose envelope, which is open at the top, pointed at the base, and may have smooth or undulate sides, colonies dendroid, divergent or compact. Protoplasm oval to fusiform, attached to the base or side of the envelope by a stalk. Chromatophores 1–2, elongate, parietal, golden yellow in colour. Eycspot crimson, apical. Spherical siliceous cysts are quite common in some species.

40. **Dinobryon bavaricum** Imhof. [syn. *Dinobryon stipitatum* Stein, *D. stipitatum* var. *bavaricum* (Imhof) Zacharias, *D. stipitatum* var. *undulatum* Lemmermann, *D. stipitatum* subsp. *eustipitatum* Pascher, *D. stipitatum* subsp. *bavaricum* Pascher, *D. stipitatum* var. *affine* (Lemmermann) Pascher, *Dinobryon elongatum* Imhof, *D. elongatum* var. *undulatum* Lemmermann, *D. elongatum* var. *affine* Lemmermann, *Dinobryon bavaricum* Imhof var. *affine* Lemmermann, *Dinobryon sociale* Ehrenberg var. *bavaricum* (Imhof.) Bachman, *Dinobryon cylindricum* Imhof var. *ceylonicum* Lemmermann]. CELLS in rather narrow dendroid colonies. ENVELOPE (*lorica*) $40\text{--}60\mu$ long \times $8\text{--}10\mu$ wide, cylindric in the upper part with undulate walls, and drawn out to a long pointed conical basal region. CHROMATOPHORES two, parietal, golden yellow. FLAGELLA two, very unequal, the longer $1\frac{1}{2}$ length of cell protoplast. (Pl. IV fig. a).

MALAYA: Malacca—in unlimed experimental fish-ponds and acid swamps.

Distribution generally in colder waters in various parts of the world.

The occurrence of this very striking species in fish ponds is surprising, since it has generally been regarded as a cold-water form. Even in India it has only been reported from high mountain waters, whereas in Malacca it was quite frequent in unlimed fish-ponds with temperatures up to 31°C . It is probable that temperature is not a determining factor for its occurrence, and some chemical factor is of greater importance, particularly pH.

41. **Dinobryon sertularia** Ehrenberg [syn. *Dinobryon thyrsoideum* Chodat, *Dinobryon sertularia* var. *thyrsoideum* (Chodat) Lemmermann]. COLONIES dendroid, often large and thick and rather bushy. ENVELOPE $25\text{--}30\mu$ long \times $8\text{--}10\mu$ wide, cylindric to slightly campanulate, swollen in the central portion, flaring at the mouth, and tapering to a short bluntly pointed basal portion. CHROMATOPHORES two, parietal, golden yellow. FLAGELLA two, unequal, the longer about body length. CYSTS quite common, spherical, with a curved apical neck to the pore, the whole enclosed in a gelatinous envelope at the mouth of the lorica. (Pl. IV figs. b, c).

MALAYA: Penang—acid swamps.

Perak—acid swamps near Ipoh.

Pahang—acid swamps near Kuantan.

Negri Sembilan—acid swamps near Seremban and Port Dickson.

Malacca—acid fish-ponds and acid swamps.

Johore—acid swamps near Muar and Yong Peng.

Singapore—acid swamps near the Royal Island Club golf course.

Worldwide in distribution.

42. **Dinobryon inflatum** Lemmermann. CELLS solitary, epiphytic. ENVELOPE broadly oval, $30-35\mu$ long \times $15-20\mu$ wide, tapering to a short stalk basally and narrowing to a short but distinct cylindrieal neck apieally. PROTOPLAST round to fusiform, attached near the base of the envelope by a fine stalk. CHROMATOPHORE one, apparently near the base, golden yellow in colour. FLAGELLA two, unequal, the longer the length of the protoplast, the other about $\frac{1}{4}$ this length. (Pl. IV fig. g).

MALAYA: Malacca—in acid swamp epiphytic on *Mougeotia*. Originally described from Northern Europe.

I have tentatively placed the Malayan material under this species, by virtue of the general shape of the envelope and the distinct neck apieally, but details of the original description are somewhat lacking.

HYALOBRYON Lauterborn 1896

Cells epiphytic, usually solitary but occasionally forming dendroid colonies, each cell in a cellulose envelope which is distinctly laminate, formed of overlapping thimble-like segments. Envelope (*lorica*) usually cylindrie, sometimes narrower towards the anterior end, occasionally spreading at the mouth, tapering at the posterior end to the attachment point or even a stalk. Protoplasm oval to spindle-shaped with usually 2 unequal chromatophores, sometimes apparently only one; chromatophores golden yellow in colour. Flagella two, unequal. Cysts where known ellipsoid with a distinct porus and plug.

43. **Hyalobryon lauterbornii** Lemmermann. CELLS solitary, epiphytic. ENVELOPE cylindric, $35-40\mu$ long \times $8-10\mu$ wide, tapering to a pointed conical base, hardly flaring at the mouth; laminations of the wall close together, starting from the base and hardly projecting, most easily seen in empty envelopes. PROTOPLAST ovoid, stalked, attached near base of the envelope. CHROMATOPHORE apparently one, golden yellow in colour. FLAGELLA two, unequal, the longer about body length, the shorter $\frac{1}{3}$ as long. (Pl. IV figs. h, i & j).

MALAYA: Malaeca—in experimental fish-ponds, epiphytic on filamentous algae.

Worldwide in distribution. This is the commonest of the species and is very variable.

The Colourless Flagellata

This is a heterogenous assemblage of genera and species with diverse affinities, which in many cases are somewhat obscure. They all have in common the complete absence of a chromatophore

and the method of nutrition may range from saprobic to completely holozoic, some forms displaying distinctly animal-like tendencies. The colourless Euglenineae, Volvocales and Dinoflagellata, all of which show well marked affinities to pigmented forms, are excluded from the account.

There are numerous ways of classifying the colourless flagellates, but since the number to be described below is small, the simplest way is to separate them on the basis of flagellation.

KEY TO THE COLOURLESS FLAGELLATA

- (i) Cells with flagella attached apically ii.
- (i) Cells with flagella attached to each lateral margin v.
- (ii) Cells with a single flagellum iii.
- (ii) Cells with two unequal flagella iv.
- (iii) Cells in stalked campanulate envelopes (lorica) arranged in a dendroid fashion *Poteriodendron*.
- (iii) Cells arranged in a granular gelatinous sheaths
Phalansterium.
- (iii) Cells with a flaring collar and enclosed in a thin lorica, usually solitary *Salpingoeca*.
- (iv) Cells naked, colonial, at end of granular stalk .. *Anthophysa*.
- (v) One flagellum at each margin *Turbomonas*.
- (v) Four flagella at each margin, two long and two short
Trepomonas.

POTERIODENDRON Stein 1878

Cells enclosed in campanulate, stalked cellulose lorica which are arranged in a dendroid fashion, with each lorica attached by means of its stalk to the inside of the lorica below. The protoplasts are usually single in a lorica, uniflagellate, the flagellum attached slightly subapically with a prominent lip on one side of the apex; this lip is retractile and can be withdrawn. A contractile vacuole is present in the basal part of the protoplast. One species is known.

44. **Poteriodendron petiolatum** Stein. LORICA campanulate, 20– 25μ long \times 8– 10μ wide, slightly widened at the mouth, with thickened walls basally and with an internal basal knob, each lorica attached inside a lower one by a thin stalk 15– 30μ long, the lowest lorica with a long stalk 60– 70μ long, with a slight basal holdfast. PROTOPLAST one in each lorica attached by

a short stalk to the base, ovoid, $8-10\mu$ long \times $4-5\mu$ wide, with a distinct apical lip which can be retracted. FLAGELLUM single, apical, slightly longer than body length. (Pl. V. fig. a). MALAYA: Malacca—in a ditch both attached and as free-swimming colonies.

Distribution world-wide.

PHALANSTERIUM Lienkowski 1865

Cells enclosed in a granular gelatinous mass, impregnated with iron; the mass may be spherical (*P. consociatum* (Fresenius) Cienkowski) with the cells peripheral, or dendroid (*P. digitatum* Stein) with the cells at the ends of the branches. Each cell is uniflagellate with the long flagellum protruding through the surface of the gelatinous mass, and the individual protoplasts each have a long narrow apical collar. One or two contractile occur at the posterior end.

45. **Phallansterium digitatum** Stein. SHEATH dendroid, with rounded very slightly concave ends, apparently hollow in the greater part, terminal branches about 10μ wide. CELL ovoid, $6-8\mu$ long \times $3-4\mu$ wide, with a long apical colour, not easily visible and through which the flagellum protrudes; cell often appearing slightly beaked sub-apically on living material. FLAGELLUM single, 10μ or more long, protruding through the ends of the gelationous sheath. (Pl. V fig. f).

MALAYA: Malacca—in acid swamps.

Worldwide in distribution.

The Malayan material shows a number of differences from the type description, being somewhat smaller. The narrow apical collars are often difficult to see in the Malayan material, and the cells often show a slightly beaked appearance not mentioned in the original. This beaked appearance may be due to contraction of the cell longitudinally, as often happens with cells under coverslips under conditions of decreased aeration. The whole organism, despite its smaller size, so closely resembles *Phalansterium digitatum* Stein that it seems logical to include it under that species, at least until further investigation proves otherwise.

SALPINGOECA J. Clark 1867

Cells enclosed in a thin envelope or lorica, which is usually constricted at the neck or mouth, and is basally attached, either sessile or stalked. The protoplast may occupy part or nearly all of the lorica, being attached to it by a thin stalk which may be long to extremely short. A characteristic feature of the protoplast is the slightly flaring funnel-like collar just below the apex and protruding beyond the mouth of the lorica. There is a single apical flagellum, and a single contractile vacuole.

46. **Salpingoeca frequentissima** (Zacharias) Lemmermann [syn. *Diplosiga frequentissima* Zacharias, *Diplosigopsis frequentissima* (Zacharias) Lemmermann]. LORICA very thin, vase shaped, 10μ long \times 5 wide, constricted at the neck and widely flaring at the mouth, sharply pointed to very shortly stalked at the base. Protoplasm nearly filling the lorica, with a flaring collar $3-5\mu$ long \times $3-5\mu$ wide projecting beyond the mouth of the lorica. FLAGELLUM single, apical, about body length or slightly longer. CONTRACTILE vacuole single, nearly central. (Pl. V. fig. b).

MALAYA: Malacca—in a fish pond, attached to *Mougeotia* and to phytoplankton.

Worldwide in distribution.

This is very common on planktonic diatoms in temperate waters, but in Malaya is more frequent on filamentous algae, where it can be very abundant indeed.

STOMATOCHONE Pascher 1942

Cells single, epiphytic on other algae, attached by a short stalk, and obliquely truncate; deeply incurved at the apex so as to form a rim or lip. Flagella two, distinctly unequal in length. There is a single basal contractile vacuole.

There are reasons for thinking that these are colourless members of the Chrysophyceae (Bourelly 1957), but in the absence of a cyst such an affinity still remains uncertain. The organisms are often as dense clusters on planktonic algae.

47. **Stomatochone infundibuliformis** Pascher. CELLS single, small, $5-7\mu$ long \times $4-5\mu$ wide, with an obliquely truncated apex, rounding posteriorly and then narrowing to a very short stalk by which it is attached. FLAGELLA two, very unequal, the longer $1\frac{1}{2}$ body length, the shorter about $\frac{1}{2}$ body length, both arising from a prominent apical depression. CONTRACTILE vacuole basal, NUCLEUS median. (Pl. V fig. d).

MALAYA: Malacca—in an acid experimental fish-pond, and in acid swamps, abundant as an epiphyte on *Pleurotaenium kayei*.

Worldwide in distribution.

The Malayan specimens seem much smaller than the size usually given for this species, but it is doubtful if such size differences are of real taxonomic significance.

ANTHOPHYSA Bory de St. Vincent 1822

Cells colonial, forming dense clumps at the ends of a prominent branched, brownish, somewhat granular, rigid gelatinous stalk. Individual cells roughly conical, with two unequal apical flagella. Stigma present or absent.

48. **Anthophysa vegetans** (O. F. Mueller) Stein. [syn. *Volvox vegetans* O. F. Mueller]. CELLS conical, $10-12\mu$ long \times 5-6 wide, obliquely truncate at the anterior end with a slight central depression, tapering posteriorly to a blunt, narrow, attachment end. FLAGELLA two, apical, unequal, the longer $1\frac{1}{2}$ body length, the shorter $\frac{1}{2}$ to $\frac{1}{3}$ body length. STIGMA absent in the Malayan material. CONTRACTILE VACUOLE sub-apical. STALK variable in length, rigid, gelatinous, thickly impregnated with iron, sparsely branched. (Pl. V. fig. e).

MALAYA: Malacca—in experimental fish-ponds, often attached to decaying debris.

Worldwide in distribution.

TURBOMONAS Prowse gen. nov.

Cells small, hyaline, flattened, obovate or sub-cordate, spirally twisted lengthwise. Flagella two, each attached midway on each lateral margin. Motion forward, swiftly gyrationis in nature, the flagella whirling at right-angles to the longitudinal axis. Nucleus one, central.

Cellulae parvae, hyalinae, applanatae, obovatae vel subcordatae, longitudinaliter obtortae. Flagella bina, unumquodque in margine utriusque lateris medio insertum. Motus cellulae porro ex natura gyrationis, flagellis ad axin longitudinalem per angulum rectum gyrantibus effectus. Nuclea uno, centrali.

Species holotypica: *T. gyrans* Prowse.

49. **Turbomonas gyrans** Prowse sp. nov. CELLS $12-13\mu$ long, $7-9\mu$ wide, $3-3.5\mu$ thick, narrowed at the anterior end, wider and almost flattened posteriorly, twisted lengthwise through 90° . propelled forward both by the gyrations of the body and the whirling of the flagella. EYESPOT absent. FLAGELLA nearly as long as the body, pointing in opposite directions. CYTOPLASM hyaline, with a few refractive granules. (Pl. V fig. c).

MALAYA: Selangor—Sg. Gombak, Kuala Lumpur Holotype Prowse 388).

And occurring elsewhere in water containing putrid material.

Holotype is deposited at Tropical Fish Culture Research Institute, Malacca.

Cellulae 12-13μ longae, 7-9μ latae, 3-3.5 μ crassae, antice angustatae, postice latiores et fere applanatae, per 90° longitudinaliter obtortae, gyrationibus corporis flagello-rumique conjunctim propulsac; ocellis nullis. Flagella corpori pacne aequilonga, opposite directa. Cytoplasma hyalinum, cum paucis granulis refractivis.

MALAYA: Selangor, Sg. Gombak, Kuala Lumpur (Holotypus).

In regionibus diversis: in aqua cum materiis putridis inquinata.

This organism is reminiscent of the Distomataceae in the way it rotates with the flagella whirling out at right angles, but it differs in having a single central nucleus. Staining with Gentian Violet suggests that although the flagella appear to be lateral in attachment, they are actually apical in origin, having fused with the margin of the cell until midway. This species should be compared with the next species, *Trepomonas rotans*, in which there are two lateral nuclei and the flagella are truly laterally attached.

TREPOMONAS Dujardin 1841

Cells mainly broadly oval, flattened in cross-section, slightly twisted, with two posterior lobe-like inflations. Nuclei two, one near each margin. Flagella two long and two short on each margin, opposite the nuclei, near the anterior end of each lobe. Cells swim by sweeping the flagella at right angles to the long axis, the body rotating and moving forward, all with a rather deliberate motion.

50. *Trepomonas rotans* Klebs. CELLS broadly oval, $18-20\mu$ long $\times 11-12\mu$ wide, rounded at the anterior end, the main body of the cell narrowing to the posterior end, but the lobes widening posteriorly and projecting slightly beyond the end of the main body, so that the posterior end of the cell is truncate and slightly concave. FLAGELLA 2 long, more than body length, 2 short about $1/3$ body length, on each margin opposite each nucleus which is about $1/3$ from the anterior end. VACUOLES fairly large and numerous. (Pl. V. fig. m).

MALAYA: Johore—stagnant water from Kota Tinggi.

Worldwide in distribution.

The slower deliberate rotating of the cell is very different from the fast whirling of *Turbomonas gyrans*.

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BIBLIOGRAPHY

ALLEGRE, C. & T. L. Jahn (1943). A survey of the genus *Phacus* Dujardin (Protozoa). Euglenoidinae. Trans. Amer. Micr. Soc. 62: 233-244, pls. 1-3.

ASMUND, B. & D. K. Hilliard (1961). Studies on Chrysophyceae from some ponds and lakes in Alaska I. Hydrobiologia 17: 237-258.

BEHRE, K. (1956). Die Süsswasseralgen der Wallacea. Expedition. Arch. f. Hydrobiol. Suppl. 23: 1-104.

BERNARD, C. (1908). Protococcacées et desmidiés d'eau douce recoltées à Java. Dept. l'Agric. Indes Néerlandaise: 1-230, plo. 1-16.

BERNARD, C. (1909). Sur quelques algues unicellulaires recoltées dans le domaine Malais. Dept. l'Agric. Indes Néerlandaise: 1-94 plo. 1-VI.

BOURELLY, P. (1957). Recherches sur les Chrysophycées Revue Algol. Mem. Hors. Serie 1.: 1-412.

CONRAD, W. (1935). Étude systematique du genre *Lepocinclis* Perty. Mem. Mus. Roy. d'Hist. Nat. Belg. 1: 1-85.

CONRAD, W. (1938). Flagellates des îles de la Sonde (Euglenacées). Bull. Mus. Roy. d'Hist. Nat. Belg. XIV No. 8: 1-20.

CONRAD, W. (1938). Notes protistologiques V. Observations sur *Uroglena soniaca* n. sp. et remarques sur le genre *Uroglena* Ehr. Bull. Mus. Roy. d'Hist. Nat. Belg. XIV No. 42: 1-27.

CONRAD, W. & L. van Meel (1951). Matériaux pour une monographie de *Trachelomonas* Ehrenberg 1834, *Strombomonas* Deflandre 1930, et *Euglena* Ehrenberg 1832, genres d'Euglenacées. Mem. Inst. Roy. Sc. Nat. Belg. 124: 1-124, plo. 1-19.

DEFLANDRE, G. (1926). Monographie du genre *Trachelomonas* Nemours.

DEFLANDRE, G. (1928). Algues d'eau douce du Venezuela (Flagellés et Chlorophycées). Rev. Algol. 3: 213-214.

DEFLANDRE, G. (1930). *Strombomonas* nouveau genre d'Euglenacées (*Trachelomonas* Ehr. pro. parte). Arch. Protistenk. 69: 551-614.

DEFLANDRE, G. (1932). Contributions à la connaissance de flagellés libres I. Ann. Protist. 3: 219-239, plo. 21-23.

ETTL, H. & J. Perman (1958). Několik nových nebo málo známých zástupců oddělení Chrysophyceae. Preslia 30: 69-75.

FOTT, B. (1957). Taxonomic drobnohledné flory našich vod. Preslia 29: 278-319.

FOTT, B. (1959). Algenkunde Jena. 481 pp.

FOTT, B. (1959). Zur Frage de Sexualität bei den Chrysomonaden Nova Hedwigia 1 (4): 115-121, pls. 22-23.

FOTT, B. (1960). Taxonomische Übertragungen und Namensänderungen unter den Algen. Preslia 32: 142-154.

FOTT, B. & J. KOMAREK (1960). Das Phytoplankton der Teiche im Teschner Schlesien. Preslia 32: 113-141, pls. 7-9.

FRITSCH, F. E. (1935). The structure and reproduction of the Algae I. Cambridge.

GOJDICS, M. (1953). The genus *Euglena*. Wisconsin.

HÜBER-PESTALOZZI, G. (1936). Phytoplankton aus seen und sumpfen Javas gesammelt von Prof. C. Schroeter. Ber. Schweiz. Bot. Ges. 46: 131-168.

HÜBER-PESTALOZZI, G. (1941). Des Phytoplankton des Süsswassers 2 (1) —Chrysophyceen. in Die Binnengewässer (Thienemann) Stuttgart.

HÜBER-PESTALOZZI, G. (1955). Das Phytoplankton des Süsswassers 4—Euglenophyceen. in Die Binnengewässer (Thienemann) Stuttgart.

LEEDALE, G. F. (1959). Amitosis in three species of Euglena. Cytologia 24 (2): 213-219.

LEFÈVRE, M. (1933). Contribution a la connaissance des flagellés d'Indochine. Ann. Crypt. Exot. 6: 258-264.

LUND, J. W. G. (1949). New or rare British Chrysophyceae I. New Phyt. 48 (3): 453-460.

LUND, J. W. G. (1952). On *Dinobryon sueicum* Lemm. var. *longispinum* Lemm. Naturalist 1952 (Oct.-Dec.): 163-166.

LUND, J. W. G. (1955). Contributions to our knowledge of British Algae XIV—Three new species from the English Lake District. Hydrobiologia 7 (3): 219-229.

LUND, J. W. G. (1960). Some new or rare Chrysophyceae from the English Lake District. Hydrobiologia 16: 97-108.

NYAGAARD, G. (1932). Contributions to our knowledge of the freshwater algae of Africa 9—Freshwater algae and phytoplankton from Transvaal. Trans. Roy. Soc. S. Africa 25: 18, fig. 19.

OYE, P. van (1925). Flagellates du Congo Belge. Bull. Soc. Roy. Bot. de Belg. 58 (1): 11-19.

PASCHER, A. (1925). Neue oder wenig bekannte Protisten XV. Arch. Protist. 50: 486-510.

PASCHER, A. (1925). Neue oder wenig bekannte Protisten XVII. Arch. Protist. 51: 549-577.

PASCHER, A. (1926). Neue oder wenig bekannte Protisten XIX Arch. Protist. 53: 459-476.

PASCHER, A. & E. LEMMERMANN (1914). Flagellatae in Die Süßwasserflora Deutschlands, Oesterreich und der Schweiz Heft. I. G. Fischer, Jena.

PASCHER, A. & W. VLK. (1942). Zur Kenntnis der Chrysophyceen des sahlitzigen Flachmoors Hrabanow bei Lissa E. Lotos 88: 163-177.

PHILIPPOSE, M. T. (1953). Contributions to our knowledge of Indian Algae 1.—Chrysophyceae. Proc. Indian Acad. Sc. 37: 232-248.

PHILIPPOSE, M. T. (1956). On some new or little known Chrysophyceae. New Phytol. 55: 289-388.

PLAYFAIR, G. I. (1921). Australian freshwater flagellates. Proc. Linn. Soc. N.S.W.: 99-146, pls. 1-9.

POCHMANN, A. (1942). Synopsis der gattung *Phacus* Arch. Protistenk 95 (2): 8-252, figs. 1-170.

POCHMANN, A. (1953). Struktur, Wachstum und Teilung der Korperhülle bei den Eugleninen. Planta 42: 478-548.

POCHMANN, A. (1955). *Helikotropis okteres* n. gen. n. spec. (Peranemataceae) und die Frage der Aetologie der Kielbildung bei farblosen Eugleninen. Oesterr. Bot. Zeitsch. 102 (1): 1-17.

POCHMANN, A. (1957). Über die Kerbungen des Zellrandes bei Phacus und eine ähnliche bei einer Chrysomonade beobachtete Erscheinung. Arch. Protist. 102: 44–83.

POCHMANN, A. (1957). Zur Frage der ontogenetischen Gestaltentwicklung der Eugleninezelle. Deutsch. Bot. Ges. 70 (7): 291–296.

POCHMANN, A. (1958). Zweiter Beitrag zur Kenntnis der Struktur Entwicklung und Zerteilung der Paramylonkorner. Oesterr. Bot. Zeitsch. 104: 321–341.

POCHMANN, A. (1959). Über die Tätigkeit der nichtkontraktilen Importvakuole und den Modus der Osmoregulation bei dem Salzflagellaten *Choanogaster* ncbst Bemerkungen über die Funktion der Pusulen. Deutsch. Bot. Ges. 72 (2): 99–108.

POCHMANN, A. (1959). Über Choanogaster einen neuen farblosen Salzflagellaten vom Urmia-See. Arch. Protist. 103: 507–530, pls. 21–22.

PREScott, G. W. (1951). Algae of the Western Great Lakes Area. Michigan. Cranbrook Inst. of Science.

PREScott, G. W. (1957). The Machras Brazilian Expedition. Chlorophyta, Euglenophyta. Contr. Sci. Los Angeles Country Mus. 11: 1–29.

PRINGSHEIM, E. G. (1942). Contributions to our knowledge of Saprophytic algae and flagellata III—*Astasia*, *Distigma*, *Menoidium* and *Rhabdomonas*. New Phytol. 41: 171–205.

PRINGSHEIM, E. G. (1948). Taxonomic problems in the Euglenineae. Biol. Rev. Camb. Phil. Soc. 23: 46–61.

PRINGSHEIM, E. G. (1956). Contributions towards a Monography of the genus *Euglena*. Nova Acta Leopold. 18 (25): 5–168.

PROWSE, G. A. (1958). The Euglenineae of Malaya. Gardens Bull. Singapore 16: 136–204.

ROSENBERG, M. (1944). On a blue-green Cryptomonad, *Chroomonas nordstedtii* Hansg. Ann. Bot. 8: 315–322.

SKUJA, H. (1949). Zur Süßwasseralgenflora Burmas. Nova. Acta Regiae Soc. Scientiarum Upsalensis 14 (5): 1–188, pls. 1–39.

SKVORTZOW, B. V. (1927). Die Euglenaceengattung *Phaeus* Dujardin. Ber. Deutsch. Bot. Ges. 46: 105–125.

SKVORTZOW, B. V. (1937). Contributions to our knowledge of the Freshwater algae of Rangoon, Burma, India I—Euglenaceen from Rangoon. Arch. Protistenk. 90: 69–87, pls. 9–12.

SKVORTZOW, B. V. (?). Species novae et minus cognitae Algarum, Flagellatarum et Phycomycetarum Asiae, Africæ, Americae et Japoniae nec non Ceylon anno 1931–45 descriptæ et illustrato per tab. 1–18. Zapiski 2: 1–34, pls. 1–18.

SUXENA, M. R. (1955). Freshwater Eugleninae from Hyderabad. India I. Jour. Indian Bot. Soc. 34 (4): 429–450.

TIFFANY, L. H. & M. E. BRITTON (1952). The Algae of Illinois Chicago 407 pp.

WANG, C. & D. NIE (1934). Notes on *Trachelomonas* in Nanking. Sinensis 5: 122–146.

WARD, H. B. & G. C. WHIPPLE edit. W. T. EDMONSON (1959). Freshwater Biology 2nd Edition. New York; 117–170 & 190–231.

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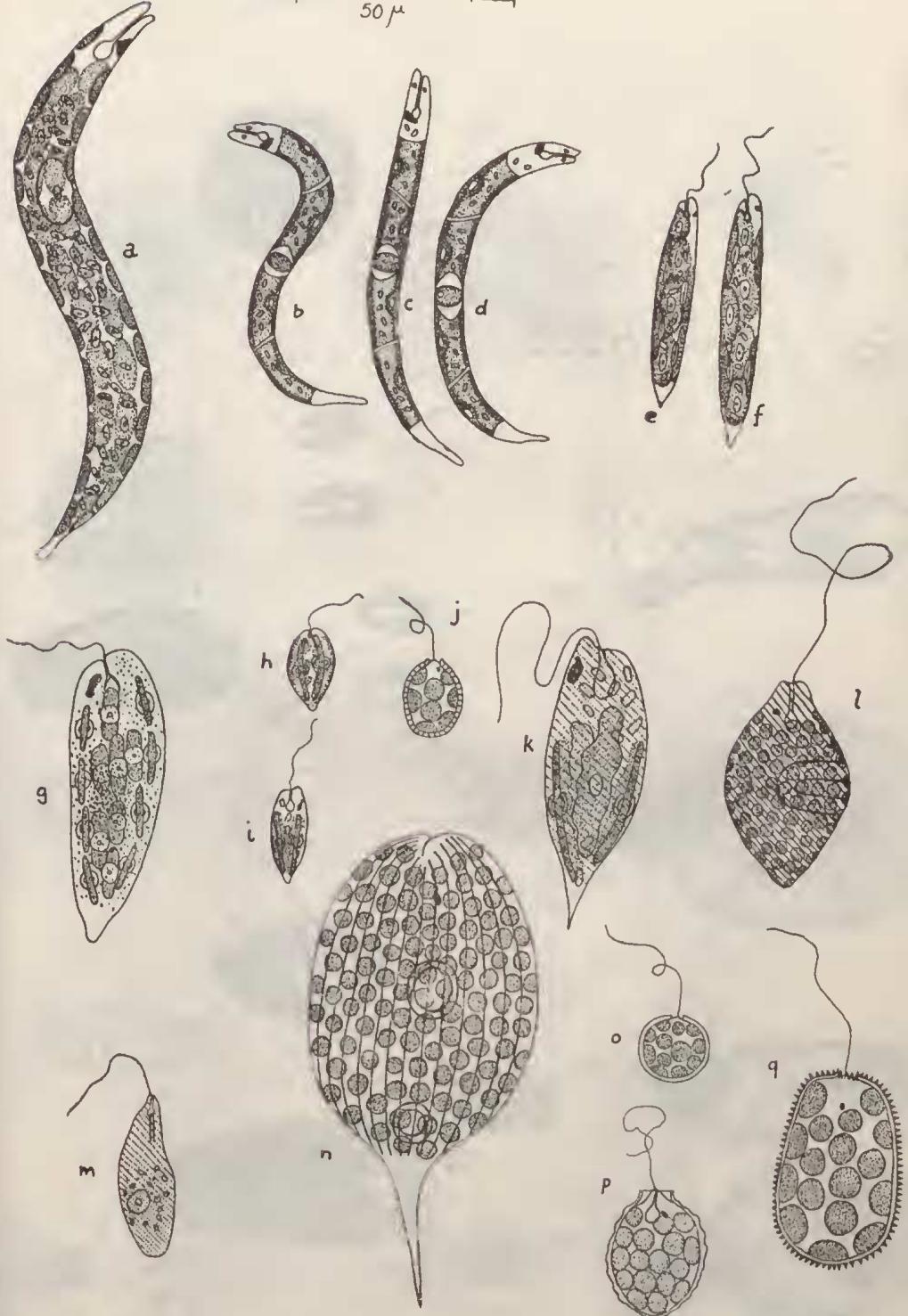
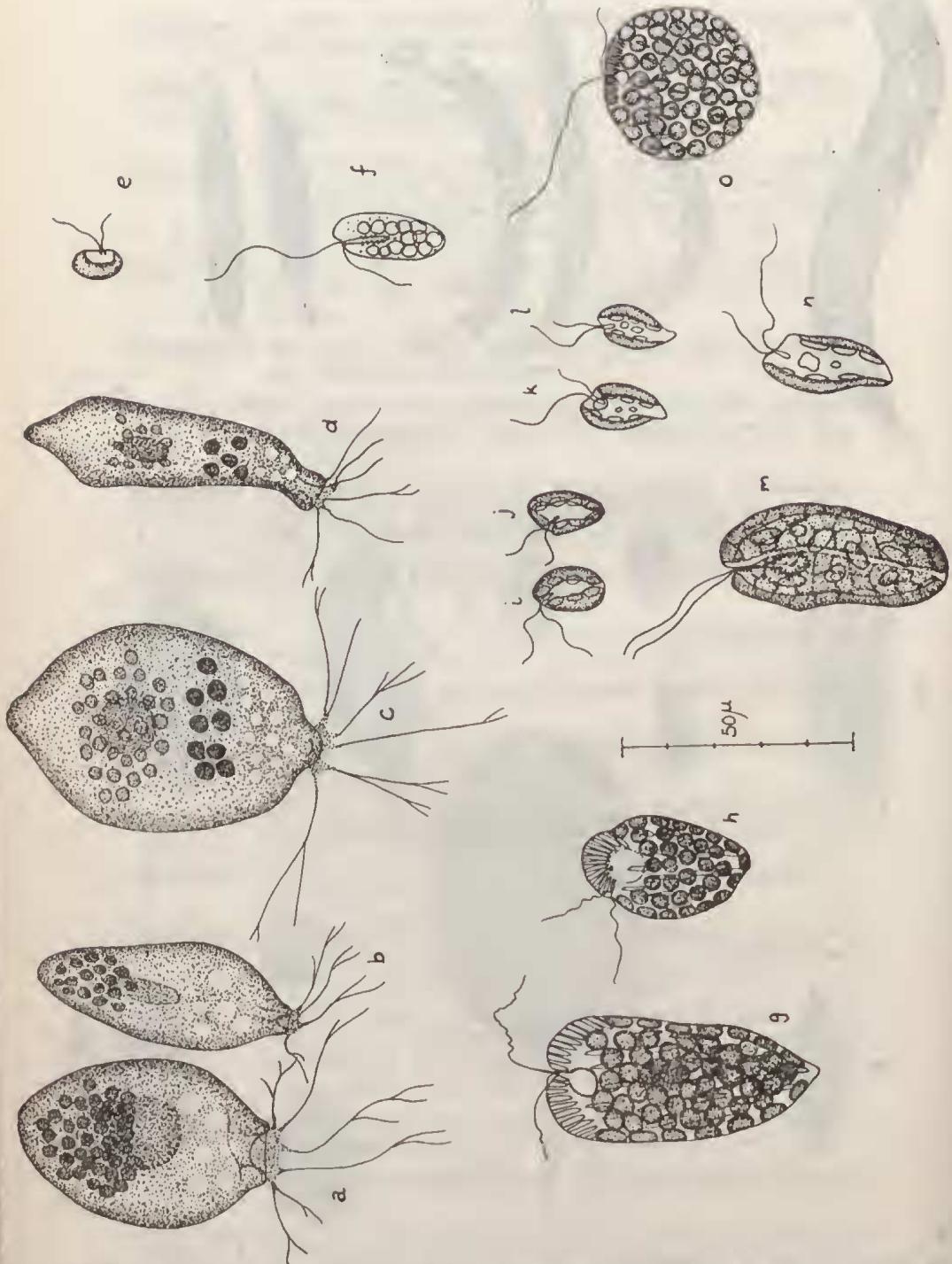


Plate I.

(a) *Euglena intermedia* (Klebs.) Schmitz var. *klebsii* Lemmermann; (b, c, d) *Euglena mutabilis* Schmitz; (e, f) *Euglena gracilis* Klebs; (g) *Euglena flava* Dangeard; (h, i) *Euglena agilis* Carter; (j) *Trachelomonas intermedia* Dangeard; (k) *Euglena exilis* Gojdics; (l) *Lepocinclus fusiformis* (Carter) Lemmermann; (m) *Peranema inflexum* Skuja; (n) *Phacus meson* Pochmann; (o) *Trachelomonas volvocinopsis* Swirensko; (p) *Strombomonas verrucosa* (Daday) Déflandre var. *chinensis* (Skvortzow) Déflandre; (q) *Trachelomonas allia* Drezenolski fa.

Plate II.
 (a, b) Rhizaspis simplex Skuja; (c, d) Rhizaspis granulata Skuja; (e) Sennia parvula Skuja; (f) Chilomonas paramecium Ehrenberg;
 (g) Gonyostomum Semen-Dessinghi; (h) Meristrichia capitata Skuja; (i, l, n) Cryptomonas phaseolus Skuja; (k) Cryptomonas



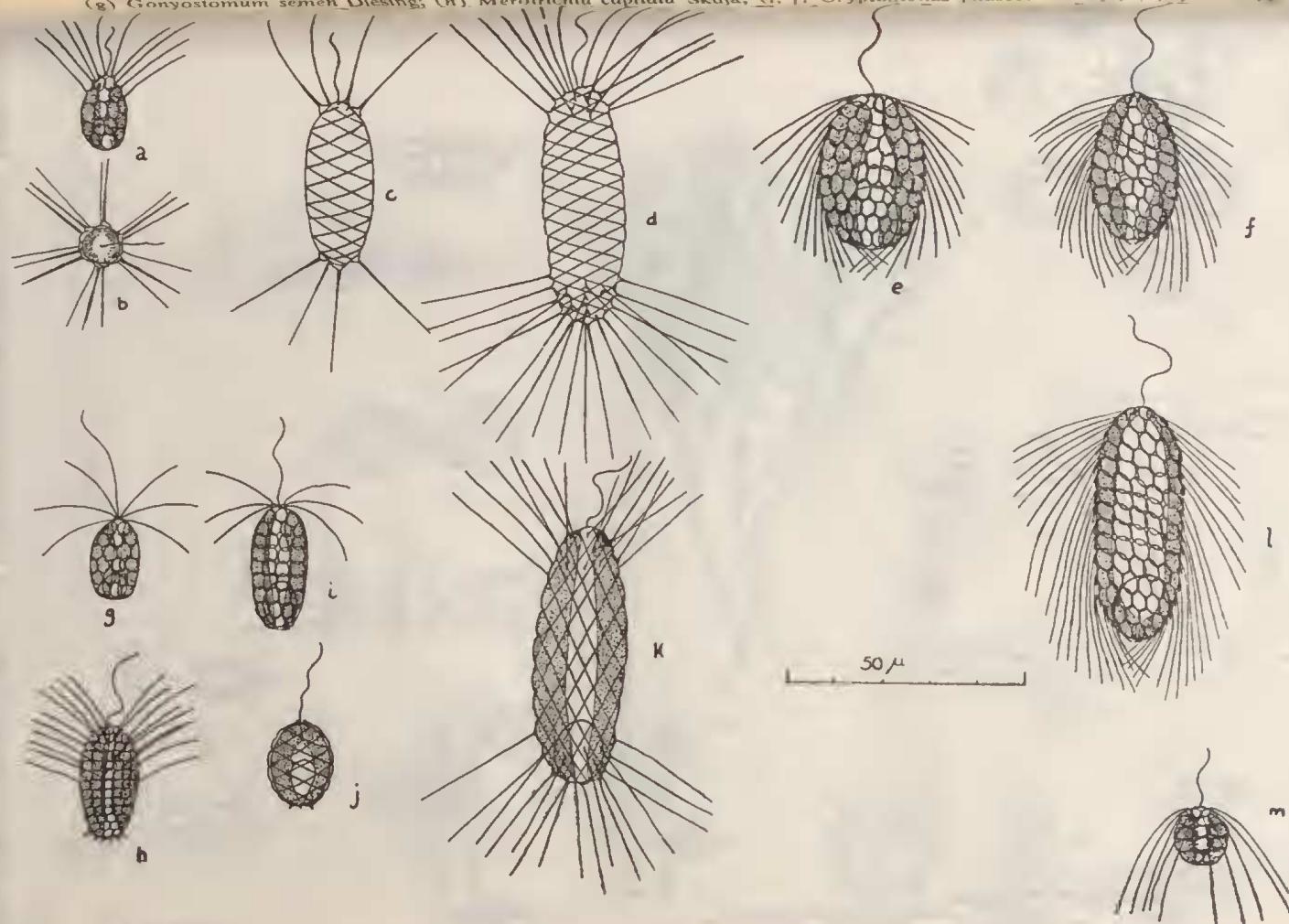


Plate III.

(a, b) *Mallomonas tonsurata* Teiling var. *alpina* (Pascher) Krieger; (c) *Mallomonas splendens* (G. S. West) Playfair; (d, k) *Mallomonas teilingioides* Prowse sp. nov.; (e, f, l) *Mallomonas acaroides* Perty; (g, i) *Mallomonas curta* (Playfair) Conrad; (h) *Mallomonas tonsurata* var. *dorsideniata* Prowse var. nov.; (j) *Mallomonas playfairii* Conrad var. *opisthiodonta* Prowse var. nov.; (m) *Mallomonas spherica* Prowse sp. nov.

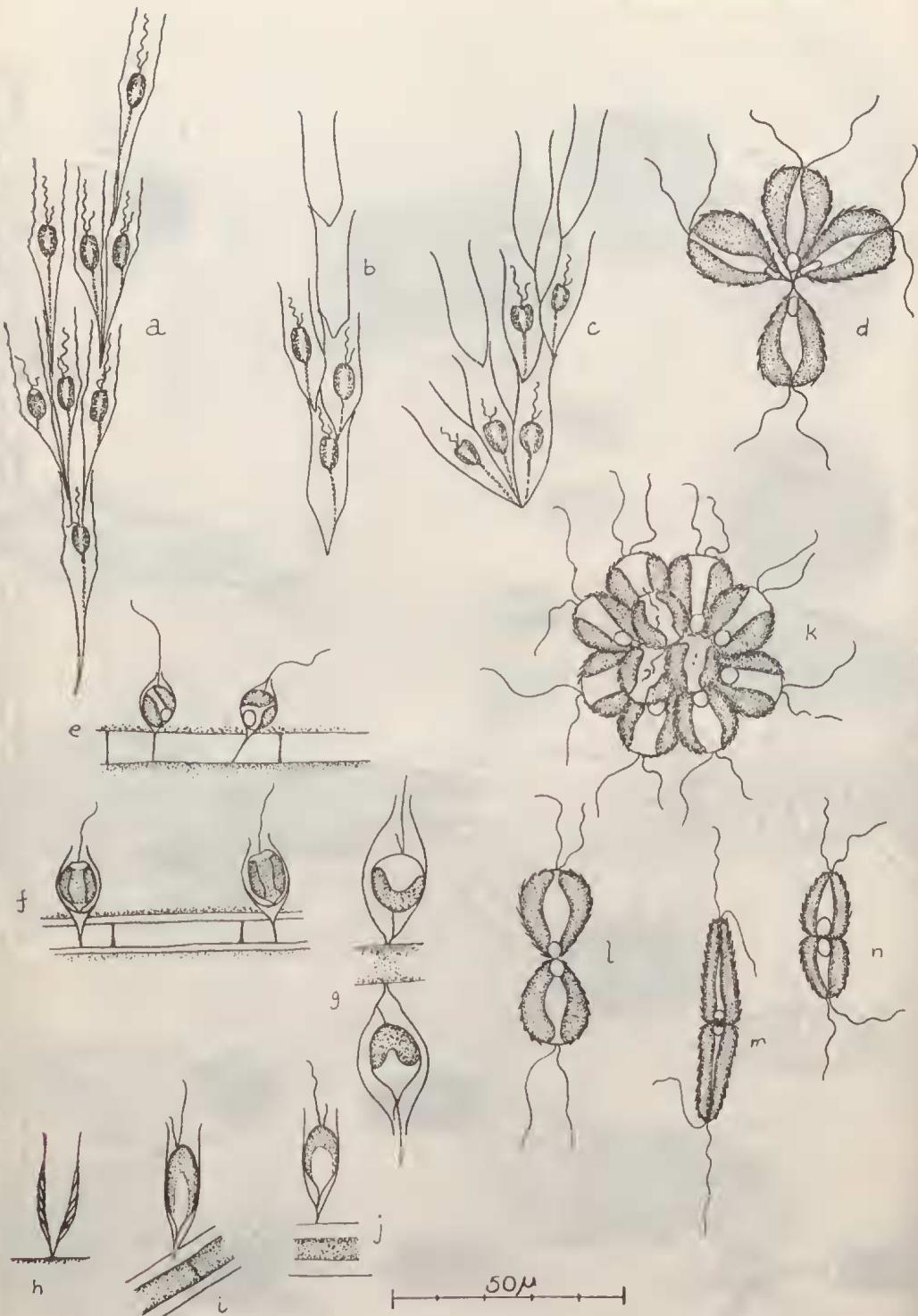


Plate IV.

- (a) *Dinobryon bavaricum* Imhof; (b, c) *Dinobryon sertularia* Ehrenberg; (d, k) *Synura uvella* Ehrenberg; (e) *Chrysopxis* sp.; (f) *Chrysopxis* sp.; (g) *Dinobryon inflatum* Lemmermann; (h, i, j) *Hyalobryon lauterbornii* Lemmermann; (l) *Synura uvella* Ehrenberg, two-celled colony; (m) *Chrysodidymus gracilis* Prowse sp. nov.; (n) *Chrysodidymus synuroides* Prowse sp. nov.

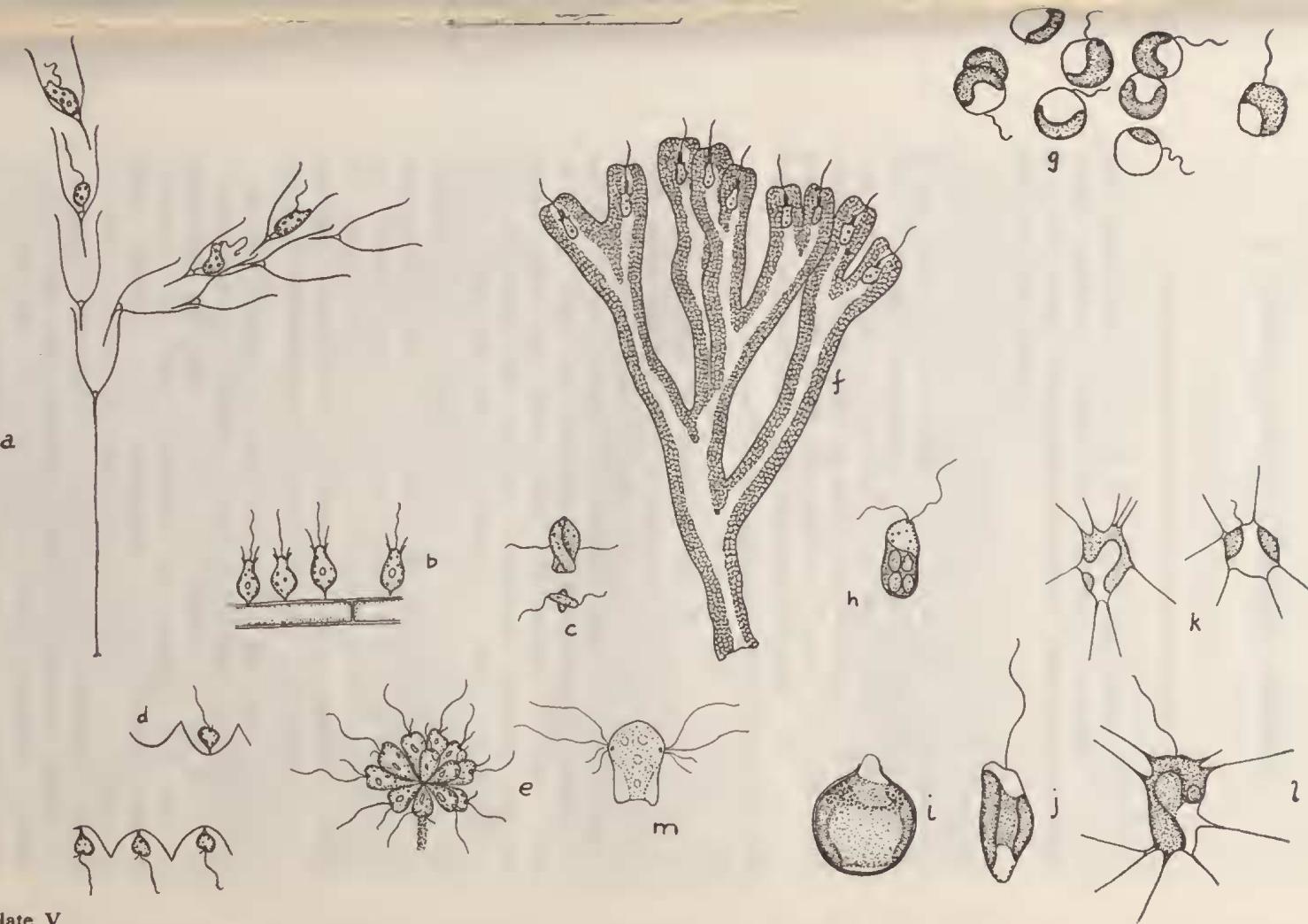


Plate V.

(a) *Poteriodendron petiolatum* Stein; (b) *Salpingoeca frequentissima* (Zacharias) Lemmermann; (c) *Turbomonas gyrans* Prowse sp. nov.; (d) *Stomatochone* sp.; (e) *Anthophysa vegetans* (O. F. Muller) Stein; (f) *Phalansterium digitatum* Stein; (g) *Chromulina sphaerica* Bachman; (h) *Ochromonas hinterzartensis* Doflein; (i-l) *Chrysamoeba radians* Klebs; (m) *Trepomonas rotans* Klebs.